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ICT IN EDUCATION

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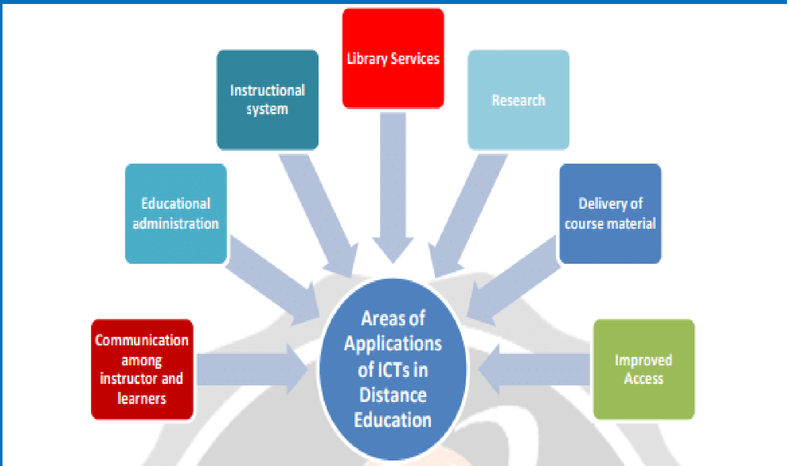

ICT IN EDUCATION

New York- 2022

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Preface

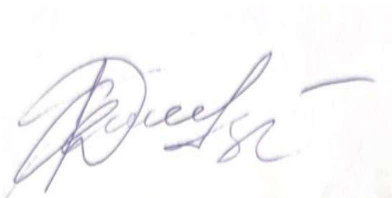
There are many reasons why you should use technology in the education. My personal reason is that technology to use in education should:

1. Support subject learning
2. Technology can be used as a tool for learning other than a media for fun and;
3. Enable you to develop student ICT capability and ICT literacy alongside subject learning.

Below I have outlined what I consider to be the pros and cons of technology in education. In general, school technology should always be used by students as a tool for learning and a means to an end by teachers. It should never be used just because it is there. Additionally, simple exposure to technology in the classroom and the haphazard teaching of ICT skills will not sufficiently develop a student's ICT capability either when it is integrated in the curriculum or as a subject itself. Here are what I consider the pros and cons to technology in education. ICT naturally brings students together where they can talk and discuss what they are doing for their work and this in turn, opens up avenues for communication thus leading to language development. Society's demands for new technology has not left out children and their needs. Students are fascinated with technology and it encourages and motivates them to learn in education. When ICT is integrated into lessons, students become more engaged in their work. This is because technology provides different opportunities to make it more fun and enjoyable in terms of teaching the same things in different ways. We all learn differently at different rates and styles and technology provide opportunities for this to occur. The integration of digital technologies or ICT is a significant part of the Azerbaijan

Curriculum for example, and this is a trend that many global governments are taking up as they begin to see the significance of ICT in education. The cases analysed in this publication are taken from different regions of Azerbaijan illustrating the global dimension of the changes that ICT bring to education systems and policies. ICT can have a transformative effect on education regardless of the economic conditions, in very advanced school systems as well as in poorly resourced ones. The choice of the policy mix varies according to particular circumstances but the vision and the potential of ICT to transform education is universal.

This is the key message that this publication attempts to articulate.



Assoc.prof. Sevinj Jabrayilzade

CONTENT

ARTIFICIAL INTELLIGENCE

In computer science, artificial intelligence (AI), sometimes called machine intelligence, is intelligence demonstrated by machines, in contrast to the natural intelligence displayed by humans. Leading AI textbooks define the field as the study of "intelligent agents": any device that perceives its environment and takes actions that maximize its chance of successfully achieving its goals. Colloquially, the term "artificial intelligence" is often used to describe machines (or computers) that mimic "cognitive" functions that humans associate with the human mind, such as "learning" and "problem solving".

As machines become increasingly capable, tasks considered to require "intelligence" are often removed from the definition of AI, a phenomenon known as the AI effect. A quip in Tesler's Theorem says "AI is whatever hasn't been done yet." For instance, optical character recognition is frequently excluded from things considered to be AI, having become a routine technology. Modern machine capabilities generally classified as AI include successfully understanding human speech, competing at the highest level in strategic game systems (such as chess and Go), autonomously operating cars, intelligent routing in content delivery networks, and military simulations.

Artificial intelligence was founded as an academic discipline in 1956, and in the years since has experienced several waves of optimism, followed by disappointment and the loss of funding (known as an "AI winter"), followed by new approaches, success and renewed funding. For most of its history, AI research has been divided into subfields that often fail to communicate with each other. These sub-fields are based on technical considerations, such as particular goals (e.g. "robotics" or "machine learning"), the use of particular tools ("logic" or artificial neural networks), or deep philosophical differences. Subfields have also been based on social factors (particular institutions or the work of particular researchers).

The traditional problems (or goals) of AI research include reasoning, knowledge representation, planning, learning, natural language processing, perception and the ability to move and manipulate objects. General intelligence is among the field's long-term goals. Approaches include statistical methods, computational intelligence, and traditional symbolic AI. Many tools are used in AI, including versions of search and mathematical optimization, artificial neural networks, and methods based on statistics, probability and economics. The AI field draws upon computer science, information engineering, mathematics, psychology, linguistics, philosophy, and many other fields.

The field was founded on the assumption that human intelligence "can be so precisely described that a machine can be made to simulate it». This raises philosophical arguments about the nature of the mind and the ethics of creating artificial beings endowed with human-like intelligence. These issues have been explored by myth, fiction and philosophy since antiquity. Some people also consider AI to be a danger to humanity if it progresses unabated. Others believe that AI, unlike previous technological revolutions, will create a risk of mass unemployment.

In the twenty-first century, AI techniques have experienced a resurgence following concurrent advances in computer power, large amounts of data, and theoretical understanding; and AI techniques have become an essential part of the technology industry, helping to solve many challenging problems in computer science, software engineering and operations research.

Silver didrachma from Cretedepicting Talos, an ancient mythical automaton with artificial intelligence

Thought-capable artificial beings appeared as storytelling devices in antiquity, and have been common in fiction, as in Mary Shelley's Frankenstein or Karel Čapek's R.U.R. (Rossum's Universal Robots). These characters and their fates raised many of the same issues now discussed in the ethics of artificial intelligence.

The study of mechanical or "formal" reasoning began with philosophers and mathematicians in antiquity. The study of mathematical logic led directly to Alan Turing's theory of computation, which suggested that a machine, by shuffling symbols as simple as "0" and "1", could simulate any conceivable act of mathematical deduction. This insight, that digital computers can simulate any process of formal reasoning, is known as the Church–Turing thesis. Along with concurrent discoveries in neurobiology, information theory and cybernetics, this led researchers to consider the possibility of building an electronic brain. Turing proposed changing the question from whether a machine was intelligent, to "whether or not it is possible for machinery to show intelligent behaviour".The first work that is now generally recognized as AI was McCullouch and Pitts' 1943 formal design for Turing-complete "artificial neurons".

The field of AI research was born at a workshop at Dartmouth College in 1956, where the term "Artificial Intelligence" was coined by John McCarthy to distinguish the field from cybernetics and escape the influence of the cyberneticist Norbert Wiener. Attendees Allen Newell (CMU), Herbert Simon (CMU), John McCarthy (MIT), Marvin Minsky (MIT) and Arthur Samuel (IBM) became the founders and leaders of AI research. They and their students produced programs that the press described as "astonishing": computers were learning checkers strategies (c. 1954) (and by 1959 were reportedly playing better than the average human), solving word problems in algebra, proving logical theorems (Logic Theorist, first run c. 1956) and speaking English. By the middle of the 1960s, research in the U.S. was heavily funded by the Department of Defense and laboratories had been established around the world. AI's founders were optimistic about the future: Herbert Simon predicted, "machines will be capable, within twenty years, of doing any work a man can do". Marvin Minsky agreed, writing, "within a generation ... the problem of creating 'artificial intelligence' will substantially be solved".

They failed to recognize the difficulty of some of the remaining tasks. Progress slowed and in 1974, in response to the criticism of Sir James Lighthill and ongoing pressure from the US Congress to fund more productive projects, both the U.S. and British governments cut off exploratory research in AI. The next few years would later be called an "AI winter", a period when obtaining funding for AI projects was difficult.

In the early 1980s, AI research was revived by the commercial success of expert systems, a form of AI program that simulated the knowledge and analytical skills of human experts. By 1985, the market for AI had reached over a billion dollars. At the same time, Japan's fifth generation computer project inspired the U.S and British governments to restore funding for academic research. However, beginning with the collapse of the Lisp Machine market in 1987, AI once again fell into disrepute, and a second, longer-lasting hiatus began.

The development of metal–oxide–semiconductor (MOS) very-large-scale integration (VLSI), in the form of complementary MOS (CMOS) transistor technology, enabled the development of practical artificial neural network (ANN) technology in the 1980s. A landmark publication in the field was the 1989 book Analog VLSI Implementation of Neural Systems by Carver A. Mead and Mohammed Ismail.

In the late 1990s and early 21st century, AI began to be used for logistics, data mining, medical diagnosis and other areas. The success was due to increasing computational power (see Moore's law and transistor count), greater emphasis on solving specific problems, new ties between AI and other fields (such as statistics, economics and mathematics), and a commitment by researchers to mathematical methods and scientific standards. Deep Blue became the first computer chess-playing system to beat a reigning world chess champion, Garry Kasparov, on 11 May 1997.

In 2011, a Jeopardy! quiz show exhibition match, IBM's question answering system, Watson, defeated the two greatest Jeopardy! champions, Brad Rutter and Ken Jennings, by a significant margin. Faster computers, algorithmic improvements, and access to large amounts of data enabled advances in machine learning and perception; data-hungry deep learning methods started to dominate accuracy benchmarks around 2012. The Kinect, which provides a 3D body–motion interface for the Xbox 360 and the Xbox One, uses algorithms that emerged from lengthy AI research as do intelligent personal assistants in smartphones. In March 2016, Alpha Go won 4 out of 5 games of Go in a match with Go champion Lee Sedol, becoming the first computer Go-playing system to beat a professional Go player without handicaps. In the 2017 Future of Go Summit, Alpha Go won a three-game match with Ke Jie, who at the time continuously held the world No. 1 ranking for two years. This marked the completion of a significant milestone in the development of Artificial Intelligence as Go is a relatively complex game, more so than Chess.

According to Bloomberg's Jack Clark, 2015 was a landmark year for artificial intelligence, with the number of software projects that use AI Google increased from a "sporadic usage" in 2012 to more than 2,700 projects. Clark also presents factual data indicating the improvements of AI since 2012 supported by lower error rates in image processing tasks. He attributes this to an increase in affordable neural networks, due to a rise in cloud computing infrastructure and to an increase in research tools and datasets. Other cited examples include Microsoft's development of a Skype system that can automatically translate from one language to another and Facebook's system that can describe images to blind people. In a 2017 survey, one in five companies reported they had "incorporated AI in some offerings or processes". Around 2016, China greatly accelerated its government funding; given its large supply of data and its rapidly increasing research output, some observers believe it may be on track to becoming an "AI superpower". However, it has been acknowledged that reports regarding artificial intelligence have tended to be exaggerated.

Computer science defines AI research as the study of "intelligent agents": any device that perceives its environment and takes actions that maximize its chance of successfully achieving its goals. A more elaborate definition characterizes AI as “a system’s ability to correctly interpret external data, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation.”

A typical AI analyzes its environment and takes actions that maximize its chance of success. An AI's intended utility function (or goal) can be simple ("1 if the AI wins a game of Go, 0 otherwise") or complex ("Do mathematically similar actions to the ones succeeded in the past"). Goals can be explicitly defined or induced. If the AI is programmed for "reinforcement learning", goals can be implicitly induced by rewarding some types of behavior or punishing others. Alternatively, an evolutionary system can induce goals by using a "fitness function" to mutate and preferentially replicate high-scoring AI systems, similar to how animals evolved to innately desire certain goals such as finding food. Some AI systems, such as nearest-neighbor, instead of reason by analogy, these systems are not generally given goals, except to the degree that goals are implicit in their training data. Such systems can still be benchmarked if the non-goal system is framed as a system whose "goal" is to successfully accomplish its narrow classification task.

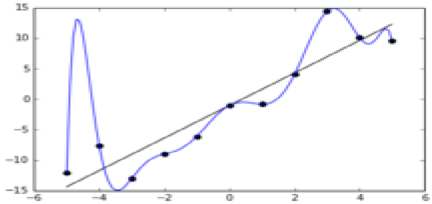
AI often revolves around the use of algorithms. An algorithm is a set of unambiguous instructions that a mechanical computer can execute. A complex algorithm is often built on top of other, simpler, algorithms. A simple example of an algorithm is the following (optimal for first player) recipe for play at tic-tac-toe:

1. If someone has a "threat" (that is, two in a row), take the remaining square. Otherwise,
2. if a move "forks" to create two threats at once, play that move. Otherwise,
3. take the center square if it is free. Otherwise,
4. if your opponent has played in a corner, take the opposite corner. Otherwise,
5. take an empty corner if one exists. Otherwise,
6. take any empty square.

Many AI algorithms are capable of learning from data; they can enhance themselves by learning new heuristics (strategies, or "rules of thumb", that have worked well in the past), or can themselves write other algorithms. Some of the "learners" described below, including Bayesian networks, decision trees, and nearest-neighbor, could theoretically, (given infinite data, time, and memory) learn to approximate any function, including which combination of mathematical functions would best describe the world[. These learners could therefore, derive all possible knowledge, by considering every possible hypothesis and matching them against the data. In practice, it is almost never possible to consider every possibility, because of the phenomenon of "combinatorial explosion", where the amount of time needed to solve a problem grows exponentially. Much of AI research involves figuring out how to identify and avoid considering broad range of possibilities that are unlikely to be beneficial. For example, when viewing a map and looking for the shortest driving route from Denver to New York in the East, one can in most cases skip looking at any path through San Francisco or other areas far to the West; thus, an AI wielding a pathfinding algorithm like A* can avoid the combinatorial explosion that would ensue if every possible route had to be ponderously considered in turn.

The earliest (and easiest to understand) approach to AI was symbolism (such as formal logic): "If an otherwise healthy adult has a fever, then they may have influenza". A second, more general, approach is Bayesian inference: "If the current patient has a fever, adjust the probability they have influenza in such-and-such way". The third major approach, extremely popular in routine business AI applications, are analogizers such as SVM and nearest-neighbor: "After examining the records of known past patients whose temperature, symptoms, age, and other factors mostly match the current patient, X% of those patients turned out to have influenza". A fourth approach is harder to intuitively understand, but is inspired by how the brain's machinery works: the artificial neural network approach uses artificial "neurons" that can learn by comparing itself to the desired output and altering the strengths of the connections between its internal neurons to "reinforce" connections that seemed to be useful. These four main approaches can overlap with each other and with evolutionary systems; for example, neural nets can learn to make inferences, to generalize, and to make analogies. Some systems implicitly or explicitly use multiple of these approaches, alongside many other AI and non-AI algorithms; the best approach is often different depending on the problem.

Learning algorithms work on the basis that strategies, algorithms, and inferences that worked well in the past are likely to continue working well in the future. These inferences can be obvious, such as "since the sun rose every morning for the last 10,000 days, it will probably rise tomorrow morning as well". They can be nuanced, such as "X% of families have geographically separate species with color variants, so there is a Y% chance that undiscovered black swansexist". Learners also work on the basis of "Occam's razor": The simplest theory that explains the data is the likeliest. Therefore, according to Occam's razor principle, a learner must be designed such that it prefers simpler theories to complex theories, except in cases where the complex theory is proven substantially better.



The blue line could be an example of overfitting a linear function due to random noise.

Settling on a bad, overly complex theory gerrymandered to fit all the past training data is known as overfitting. Many systems attempt to reduce overfitting by rewarding a theory in accordance with how well it fits the data, but penalizing the theory in accordance with how complex the theory is Besides classic overfitting, learners can also disappoint by "learning the wrong lesson". A toy example is that an image classifier trained only on pictures of brown horses and black cats might conclude that all brown patches are likely to be horses. A real-world example is that, unlike humans, current image classifiers don't determine the spatial relationship between components of the picture; instead, they learn abstract patterns of pixels that humans are oblivious to, but that linearly correlate with images of certain types of real objects. Faintly superimposing such a pattern on a legitimate image results in an "adversarial" image that the system misclassifies.

A self-driving car system may use a neural network to determine which parts of the picture seem to match previous training images of pedestrians, and then model those areas as slow-moving but somewhat unpredictable rectangular prisms that must be avoided.

Compared with humans, existing AI lacks several features of human "commonsense reasoning"; most notably, humans have powerful mechanisms for reasoning about "naïve physics" such as space, time, and physical interactions. This enables even young children to easily make inferences like "If I roll this pen off a table, it will fall on the floor". Humans also have a powerful mechanism of "folk psychology" that helps them to interpret natural-language sentences such as "The city councilmen refused the demonstrators a permit because they advocated violence". (A generic AI has difficulty discerning whether the ones alleged to be advocating violence are the councilmen or the demonstrators.) This lack of "common knowledge" means that AI often makes different mistakes than humans make, in ways that can seem incomprehensible. For example, existing self-driving cars cannot reason about the location nor the intentions of pedestrians in the exact way that humans do, and instead must use non-human modes of reasoning to avoid accidents.

The cognitive capabilities of current architectures are very limited, using only a simplified version of what intelligence is really capable of. For instance, the human mind has come up with ways to reason beyond measure and logical explanations to different occurrences in life.

What would have been otherwise straightforward, an equivalently difficult problem may be challenging to solve computationally as opposed to using the human mind. This gives rise to two classes of models: structuralist and functionalist.

The structural models aim to loosely mimic the basic intelligence operations of the mind such as reasoning and logic.

The functional model refers to the correlating data to its computed counterpart.

The overall research goal of artificial intelligence is to create technology that allows computers and machines to function in an intelligent manner.

The general problem of simulating (or creating) intelligence has been broken down into sub-problems.

These consist of particular traits or capabilities that researchers expect an intelligent system to display.

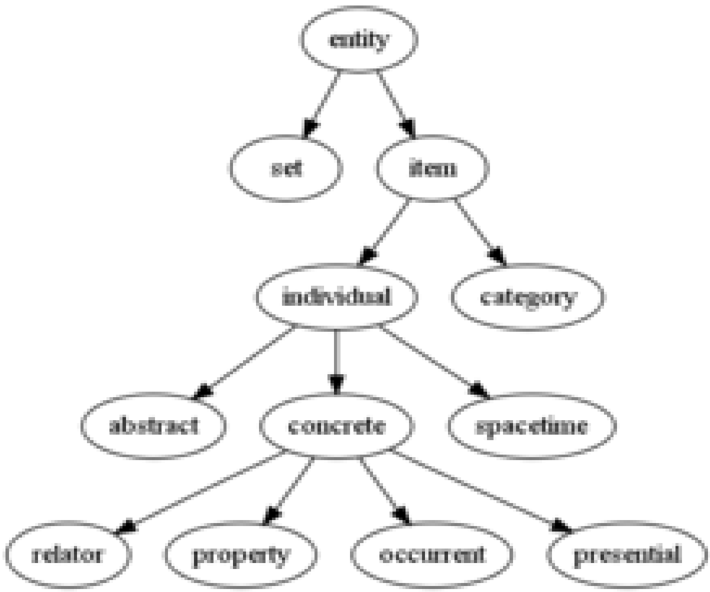
The traits described below have received the most attention.

Early researchers developed algorithms that imitated step-by-step reasoning that humans use when they solve puzzles or make logical deductions. By the late 1980s and 1990s, AI research had developed methods for dealing with uncertain or incomplete information, employing concepts from probability and economics.

These algorithms proved to be insufficient for solving large reasoning problems, because they experienced a "combinatorial explosion": they became exponentially slower as the problems grew larger. In fact, even humans rarely use the step-by-step deduction that early AI research was able to model.

They solve most of their problems using fast, intuitive judgments.

Knowledge representation



An ontology represents knowledge as a set of concepts within a domain and the relationships between those concepts.

Knowledge representation and knowledge engineering are central to classical AI research. Some "expert systems" attempt to gather together explicit knowledge possessed by experts in some narrow domain. In addition, some projects attempt to gather the "commonsense knowledge" known to the average person into a database containing extensive knowledge about the world. Among the things a comprehensive commonsense knowledge base would contain are: objects, properties, categories and relations between objects; situations, events, states and time; causes and effects; knowledge about knowledge (what we know about what other people know); and many other, less well researched domains. A representation of "what exists" is an ontology: the set of objects, relations, concepts, and properties formally described so that software agents can interpret them. The semantics of these are captured as description logic concepts, roles, and individuals, and typically implemented as classes, properties, and individuals in the Web Ontology Language. The most general ontologies are called upper ontologies, which attempt to provide a foundation for all other knowledge by acting as mediators between domain ontologies that cover specific knowledge about a particular knowledge domain (field of interest or area of concern). Such formal knowledge representations can be used in content-based indexing and retrieval, scene interpretation, clinical decision support, knowledge discovery (mining "interesting" and actionable inferences from large databases), and other areas.

Among the most difficult problems in knowledge representation are:

Default reasoning and the qualification problem

Many of the things people know take the form of "working assumptions". For example, if a bird comes up in conversation, people typically picture an animal that is fist-sized, sings, and flies. None of these things are true about all birds. John McCarthy identified this problem in 1969 as the qualification problem: for any commonsense rule that AI researchers care to represent, there tend to be a huge number of exceptions. Almost nothing is simply true or false in the way that abstract logic requires. AI research has explored a number of solutions to this problem

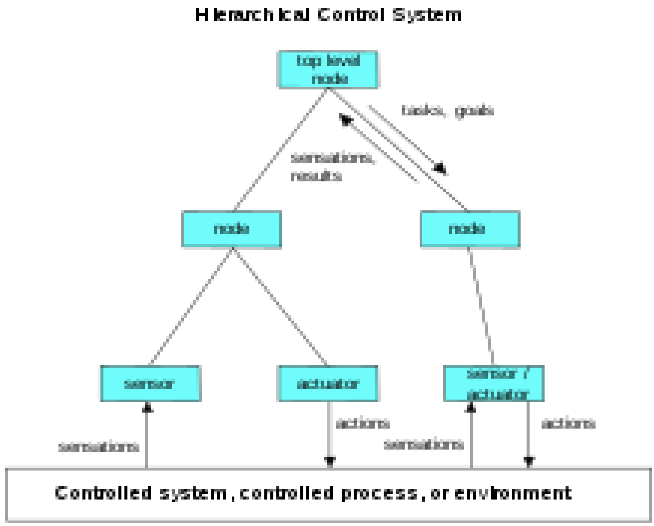
Breadth of commonsense knowledge

The number of atomic facts that the average person knows is very large. Research projects that attempt to build a complete knowledge base of commonsense knowledge (e.g., Cyc) require enormous amounts of laborious ontological engineering—they must be built, by hand, one complicated concept at a time.

Subsymbolic form of some commonsense knowledge

Much of what people know is not represented as "facts" or "statements" that they could express verbally. For example, a chess master will avoid a particular chess position because it "feels too exposed" or an art critic can take one look at a statue and realize that it is a fake. These are non-conscious and sub-symbolic intuitions or tendencies in the human brain. Knowledge like this informs, supports and provides a context for symbolic, conscious knowledge. As with the related problem of sub-symbolic reasoning, it is hoped that situated AI, computational intelligence, or statistical AI will provide ways to represent this kind of knowledge.

Planning



A hierarchical control system is a form of control system in which a set of devices and governing software is arranged in a hierarchy.

Intelligent agents must be able to set goals and achieve them. They need a way to visualize the future—a representation of the state of the world and be able to make predictions about how their actions will change it—and be able to make choices that maximize the utility (or "value") of available choices.

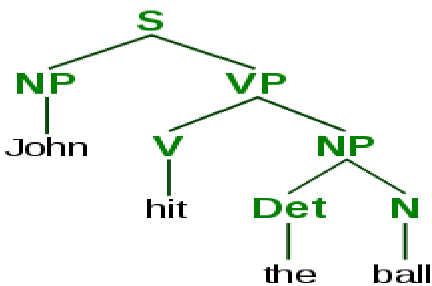
In classical planning problems, the agent can assume that it is the only system acting in the world, allowing the agent to be certain of the consequences of its actions. However, if the agent is not the only actor, then it requires that the agent can reason under uncertainty. This calls for an agent that can not only assess its environment and make predictions, but also evaluate its predictions and adapt based on its assessment.

Multi-agent planning uses the cooperation and competition of many agents to achieve a given goal. Emergent behavior such as this is used by evolutionary algorithms and swarm intelligence.

Machine learning (ML), a fundamental concept of AI research since the field's inception, is the study of computer algorithms that improve automatically through experience.

Unsupervised learning is the ability to find patterns in a stream of input, without requiring a human to label the inputs first. Supervised learning includes both classification and numerical regression, which requires a human to label the input data first. Classification is used to determine what category something belongs in, and occurs after a program sees a number of examples of things from several categories. Regression is the attempt to produce a function that describes the relationship between inputs and outputs and predicts how the outputs should change as the inputs change. Both classifiers and regression learners can be viewed as "function approximators" trying to learn an unknown (possibly implicit) function; for example, a spam classifier can be viewed as learning a function that maps from the text of an email to one of two categories, "spam" or "not spam". Computational learning theory can assess learners by computational complexity, by sample complexity (how much data is required), or by other notions of optimization. In reinforcement learning the agent is rewarded for good responses and punished for bad ones. The agent uses this sequence of rewards and punishments to form a strategy for operating in its problem space.

Natural language processing



A parse tree represents the syntactic structure of a sentence according to some formal grammar.

Natural language processing (NLP) gives machines the ability to read and understand human language. A sufficiently powerful natural language processing system would enable natural-language user interfaces and the acquisition of knowledge directly from human-written sources, such as newswire texts. Some straightforward applications of natural language processing include information retrieval, text mining, question answering and machine translation. Many current approaches use word co-occurrence frequencies to construct syntactic representations of text. "Keyword spotting" strategies for search are popular and scalable but dumb; a search query for "dog" might only match documents with the literal word "dog" and miss a document with the word "poodle". "Lexical affinity" strategies use the occurrence of words such as "accident" to assess the sentiment of a document. Modern statistical NLP approaches can combine all these strategies as well as others, and often achieve acceptable accuracy at the page or paragraph level, but continue to lack the semantic understanding required to classify isolated sentences well. Besides the usual difficulties with encoding semantic commonsense knowledge, existing semantic NLP sometimes scales too poorly to be viable in business applications. Beyond semantic NLP, the ultimate goal of "narrative" NLP is to embody a full understanding of commonsense reasoning.

Machine perception, Computer vision, and Speech recognition

Feature detection (pictured: edge detection) helps AI compose informative abstract structures out of raw data.

Machine perception is the ability to use input from sensors (such as cameras (visible spectrum or infrared), microphones, wireless signals, and active lidar, sonar, radar, and tactile sensors) to deduce aspects of the world. Applications include speech recognition, facial recognition, and object recognition. Computer vision is the ability to analyze visual input. Such input is usually ambiguous; a giant, fifty-meter-tall pedestrian far away may produce exactly the same pixels as a nearby normal-sized pedestrian, requiring the AI to judge the relative likelihood and reasonableness of different interpretations, for example by using its "object model" to assess that fifty-meter pedestrians do not exist.

AI is heavily used in robotics. Advanced robotic arms and other industrial robots, widely used in modern factories, can learn from experience how to move efficiently despite the presence of friction and gear slippage. A modern mobile robot, when given a small, static, and visible environment, can easily determine its location and map its environment; however, dynamic environments, such as (in endoscopy) the interior of a patient's breathing body, pose a greater challenge.

Motion planning is the process of breaking down a movement task into "primitives" such as individual joint movements.

Such movement often involves compliant motion, a process where movement requires maintaining physical contact with an object.

Moravec's paradox generalizes that low-level sensorimotor skills that humans take for granted are, counterintuitively, difficult to program into a robot; the paradox is named after Hans Moravec, who stated in 1988 that "it is comparatively easy to make computers exhibit adult level performance on intelligence tests or playing checkers, and difficult or impossible to give them the skills of a one-year-old when it comes to perception and mobility".

This is attributed to the fact that, unlike checkers, physical dexterity has been a direct target of natural selection for millions of years.

Kismet, a robot with rudimentary social skills

Moravec's paradox can be extended to many forms of social intelligence. Distributed multi-agent coordination of autonomous vehicles remains a difficult problem. Affective computing is an interdisciplinary umbrella that comprises systems which recognize, interpret, process, or simulate human affects. Moderate successes related to affective computing include textual sentiment analysis and, more recently, multimodal affect analysis (see multimodal sentiment analysis), wherein AI classifies the affects displayed by a videotaped subject.

In the long run, social skills and an understanding of human emotion and game theory would be valuable to a social agent. Being able to predict the actions of others by understanding their motives and emotional states would allow an agent to make better decisions. Some computer systems mimic human emotion and expressions to appear more sensitive to the emotional dynamics of human interaction, or to otherwise facilitate human–computer interaction. Similarly, some virtual assistants are programmed to speak conversationally or even to banter humorously; this tends to give naïve users an unrealistic conception of how intelligent existing computer agents actually are.

Historically, projects such as the Cyc knowledge base (1984) and the massive Japanese Fifth Generation Computer Systems initiative (1982–1992) attempted to cover the breadth of human cognition. These early projects failed to escape the limitations of non-quantitative symbolic logic models and, in retrospect, greatly underestimated the difficulty of cross-domain AI. Nowadays, the vast majority of current AI researchers work instead on tractable "narrow AI" applications (such as medical diagnosis or automobile navigation). Many researchers predict that such "narrow AI" work in different individual domains will eventually be incorporated into a machine with artificial general intelligence (AGI), combining most of the narrow skills mentioned in this article and at some point even exceeding human ability in most or all these areas. Many advances have general, cross-domain significance. One high-profile example is that DeepMind in the 2010s developed a "generalized artificial intelligence" that could learn many diverse Atari games on its own, and later developed a variant of the system which succeeds at sequential learning. Besides transfer learning, hypothetical AGI breakthroughs could include the development of reflective architectures that can engage in decision-theoretic metareasoning, and figuring out how to "slurp up" a comprehensive knowledge base from the entire unstructured Web. Some argue that some kind of (currently-undiscovered) conceptually straightforward, but mathematically difficult, "Master Algorithm" could lead to AGI.Finally, a few "emergent" approaches look to simulating human intelligence extremely closely, and believe that anthropomorphic features like an artificial brain or simulated child development may someday reach a critical point where general intelligence emerges.

Many of the problems in this article may also require general intelligence, if machines are to solve the problems as well as people do. For example, even specific straightforward tasks, like machine translation, require that a machine read and write in both languages (NLP), follow the author's argument (reason), know what is being talked about (knowledge), and faithfully reproduce the author's original intent (social intelligence). A problem like machine translation is considered "AI-complete", because all of these problems need to be solved simultaneously in order to reach human-level machine performance.

There is no established unifying theory or paradigm that guides AI research. Researchers disagree about many issues. A few of the most long standing questions that have remained unanswered are these: should artificial intelligence simulate natural intelligence by studying psychology or neurobiology? Or is human biology as irrelevant to AI research as bird biology is to aeronautical engineering? Can intelligent behavior be described using simple, elegant principles (such as logic or optimization)? Or does it necessarily require solving a large number of completely unrelated problems?

In the 1940s and 1950s, a number of researchers explored the connection between neurobiology, information theory, and cybernetics. Some of them built machines that used electronic networks to exhibit rudimentary intelligence, such as W. Grey Walter's turtles and the Johns Hopkins Beast. Many of these researchers gathered for meetings of the Teleological Society at Princeton University and the Ratio Club in England. By 1960, this approach was largely abandoned, although elements of it would be revived in the 1980s.

When access to digital computers became possible in the mid 1950s, AI research began to explore the possibility that human intelligence could be reduced to symbol manipulation. The research was centered in three institutions: Carnegie Mellon University, Stanford and MIT, and as described below, each one developed its own style of research. John Haugeland named these symbolic approaches to AI "good old fashioned AI" or "GOFAI". During the 1960s, symbolic approaches had achieved great success at simulating high-level "thinking" in small demonstration programs. Approaches based on cybernetics or artificial neural networks were abandoned or pushed into the background. Researchers in the 1960s and the 1970s were convinced that symbolic approaches would eventually succeed in creating a machine with artificial general intelligence and considered this the goal of their field.

Economist Herbert Simon and Allen Newell studied human problem-solving skills and attempted to formalize them, and their work laid the foundations of the field of artificial intelligence, as well as cognitive science, operations research and management science. Their research team used the results of psychological experiments to develop programs that simulated the techniques that people used to solve problems. This tradition, centered at Carnegie Mellon University would eventually culminate in the development of the Soar architecture in the middle 1980s.

Unlike Simon and Newell, John McCarthy felt that machines did not need to simulate human thought, but should instead try to find the essence of abstract reasoning and problem-solving, regardless whether people used the same algorithms. His laboratory at Stanford (SAIL) focused on using formal logic to solve a wide variety of problems, including knowledge representation, planning and learning. Logic was also the focus of the work at the University of Edinburgh and elsewhere in Europe which led to the development of the programming language Prolog and the science of logic programming.

Researchers at MIT (such as Marvin Minsky and Seymour Papert) found that solving difficult problems in vision and natural language processing required ad-hoc solutions—they argued that there was no simple and general principle (like logic) that would capture all the aspects of intelligent behavior. Roger Schank described their "anti-logic" approaches as "scruffy" (as opposed to the "neat" paradigms at CMU and Stanford). Commonsense knowledge bases(such as Doug Lenat's Cyc) are an example of "scruffy" AI, since they must be built by hand, one complicated concept at a time.

When computers with large memories became available around 1970, researchers from all three traditions began to build knowledge into AI applications. This "knowledge revolution" led to the development and deployment of expert systems (introduced by Edward Feigenbaum), the first truly successful form of AI software. A key component of the system architecture for all expert systems is the knowledge base, which stores facts and rules that illustrate AI. The knowledge revolution was also driven by the realization that enormous amounts of knowledge would be required by many simple AI applications.

By the 1980s, progress in symbolic AI seemed to stall and many believed that symbolic systems would never be able to imitate all the processes of human cognition, especially perception, robotics, learning and pattern recognition. A number of researchers began to look into "sub-symbolic" approaches to specific AI problems. Sub-symbolic methods manage to approach intelligence without specific representations of knowledge.

This includes embodied, situated, behavior-based, and nouvelle AI. Researchers from the related field of robotics, such as Rodney Brooks, rejected symbolic AI and focused on the basic engineering problems that would allow robots to move and survive. Their work revived the non-symbolic point of view of the early cybernetics researchers of the 1950s and reintroduced the use of control theory in AI. This coincided with the development of the embodied mind thesisin the related field of cognitive science: the idea that aspects of the body (such as movement, perception and visualization) are required for higher intelligence.

Within developmental robotics, developmental learning approaches are elaborated upon to allow robots to accumulate repertoires of novel skills through autonomous self-exploration, social interaction with human teachers, and the use of guidance mechanisms (active learning, maturation, motor synergies, etc.).

COMPUTATIONAL INTELLIGENCE AND SOFT COMPUTING

Interest in neural networks and "connectionism" was revived by David Rumelhart and others in the middle of the 1980s. Artificial neural networks are an example of soft computing—they are solutions to problems which cannot be solved with complete logical certainty, and where an approximate solution is often sufficient. Other soft computing approaches to AI include fuzzy systems, Grey system theory, evolutionary computation and many statistical tools. The application of soft computing to AI is studied collectively by the emerging discipline of computational intelligence.

Much of traditional GOFAI got bogged down on ad hoc patches to symbolic computation that worked on their own toy models but failed to generalize to real-world results. However, around the 1990s, AI researchers adopted sophisticated mathematical tools, such as hidden Markov models HMM), information theory, and normative Bayesian decision theory to compare or to unify competing architectures. The shared mathematical language permitted a high level of collaboration with more established fields (like mathematics, economics or operations research). Compared with GOFAI, new "statistical learning" techniques such as HMM and neural networks were gaining higher levels of accuracy in many practical domains such as data mining, without necessarily acquiring a semantic understanding of the datasets. The increased successes with real-world data led to increasing emphasis on comparing different approaches against shared test data to see which approach performed best in a broader context than that provided by idiosyncratic toy models; AI research was becoming more scientific. Nowadays results of experiments are often rigorously measurable, and are sometimes (with difficulty) reproducible. Different statistical learning techniques have different limitations; for example, basic HMM cannot model the infinite possible combinations of natural language. Critics note that the shift from GOFAI to statistical learning is often also a shift away from explainable AI. In AGI research, some scholars caution against over-reliance on statistical learning, and argue that continuing research into GOFAI will still be necessary to attain general intelligence.

Integrating the approaches

An intelligent agent is a system that perceives its environment and takes actions which maximize its chances of success. The simplest intelligent agents are programs that solve specific problems. More complicated agents include human beings and organizations of human beings (such as firms). The paradigm allows researchers to directly compare or even combine different approaches to isolated problems, by asking which agent is best at maximizing a given "goal function". An agent that solves a specific problem can use any approach that works—some agents are symbolic and logical, some are sub-symbolic artificial neural networks and others may use new approaches. The paradigm also gives researchers a common language to communicate with other fields—such as decision theory and economics—that also use concepts of abstract agents. Building a complete agent requires researchers to address realistic problems of integration; for example, because sensory systems give uncertain information about the environment, planning systems must be able to function in the presence of uncertainty. The intelligent agent paradigm became widely accepted during the 1990s.

Agent architectures and cognitive architectures

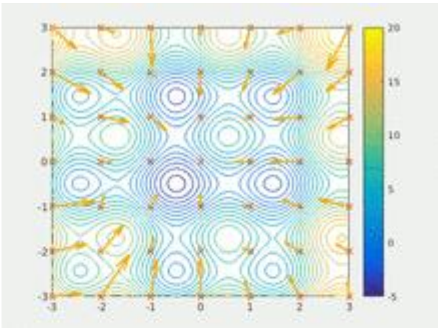
Researchers have designed systems to build intelligent systems out of interacting intelligent agents in a multi-agent system. A hierarchical control system provides a bridge between sub-symbolic AI at its lowest, reactive levels and traditional symbolic AI at its highest levels, where relaxed time constraints permit planning and world modeling. Some cognitive architectures are custom-built to solve a narrow problem; others, such as Soar, are designed to mimic human cognition and to provide insight into general intelligence. Modern extensions of Soar are hybrid intelligent systems that include both symbolic and sub-symbolic components.

AI has developed many tools to solve the most difficult problems in computer science. A few of the most general of these methods are discussed below.

Many problems in AI can be solved in theory by intelligently searching through many possible solutions: Reasoning can be reduced to performing a search. For example, logical proof can be viewed as searching for a path that leads from premises to conclusions, where each step is the application of an inference rule. Planning algorithms search through trees of goals and sub goals, attempting to find a path to a target goal, a process called means-ends analysis. Robotics algorithms for moving limbs and grasping objects use local searches in configuration space. Many learning algorithms use search algorithms based on optimization.

Simple exhaustive searches are rarely sufficient for most real-world problems: the search space (the number of places to search) quickly grows to astronomical numbers. The result is a search that is too slow or never completes. The solution, for many problems, is to use "heuristics" or "rules of thumb" that prioritize choices in favor of those that are more likely to reach a goal and to do so in a shorter number of steps. In some search methodologies heuristics can also serve to entirely eliminate some choices that are unlikely to lead to a goal (called "pruning the search tree"). Heuristics supply the program with a "best guess" for the path on which the solution lies. Heuristics limit the search for solutions into a smaller sample size.

A very different kind of search came to prominence in the 1990s, based on the mathematical theory of optimization. For many problems, it is possible to begin the search with some form of a guess and then refine the guess incrementally until no more refinements can be made. These algorithms can be visualized as blind hill climbing: we begin the search at a random point on the landscape, and then, by jumps or steps, we keep moving our guess uphill, until we reach the top. Other optimization algorithms are simulated annealing, beam search and random optimization.



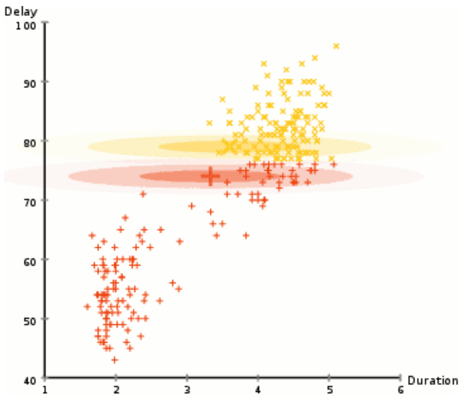
A particle swarm seeking the global minimum

Evolutionary computation uses a form of optimization search. For example, they may begin with a population of organisms (the guesses) and then allow them to mutate and recombine, selectingonly the fittest to survive each generation (refining the guesses). Classic evolutionary algorithms include genetic algorithms, gene expression programming, and genetic programming. Alternatively, distributed search processes can coordinate via swarm intelligence algorithms. Two popular swarm algorithms used in search are particle swarm optimization (inspired by bird flocking) and ant colony optimization (inspired by ant trails).

Logic is used for knowledge representation and problem solving, but it can be applied to other problems as well. For example, the satplan algorithm uses logic for planning and inductive logic programming is a method for learning.

Several different forms of logic are used in AI research. Propositional logic involves truth functions such as "or" and "not". First-order logic adds quantifiers and predicates, and can express facts about objects, their properties, and their relations with each other. Fuzzy set theory assigns a "degree of truth" (between 0 and 1) to vague statements such as "Alice is old" (or rich, or tall, or hungry) that are too linguistically imprecise to be completely true or false. Fuzzy logic is successfully used in control systems to allow experts to contribute vague rules such as "if you are close to the destination station and moving fast, increase the train's brake pressure"; these vague rules can then be numerically refined within the system. Fuzzy logic fails to scale well in knowledge bases; many AI researchers question the validity of chaining fuzzy-logic inferences.

Default logics, non-monotonic logics and circumscription are forms of logic designed to help with default reasoning and the qualification problem. Several extensions of logic have been designed to handle specific domains of knowledge, such as: description logics; situation calculus, event calculus and fluent calculus (for representing events and time); causal calculus; belief calculus (belief revision); and modal logics. Logics to model contradictory or inconsistent statements arising in multi-agent systems have also been designed, such as paraconsistent logics.



Expectation-maximization clustering of Old Faithful eruption data starts from a random guess but then successfully converges on an accurate clustering of the two physically distinct modes of eruption.

Many problems in AI (in reasoning, planning, learning, perception, and robotics) require the agent to operate with incomplete or uncertain information. AI researchers have devised a number of powerful tools to solve these problems using methods from probability theory and economics.

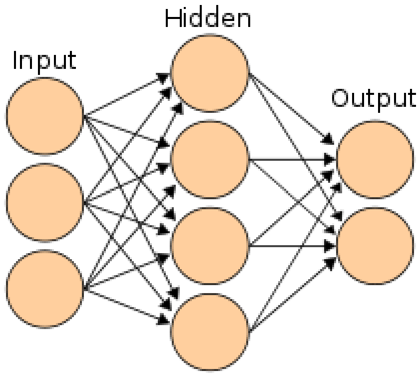
Bayesian networks are a very general tool that can be used for various problems: reasoning (using the Bayesian inference algorithm), learning (using the expectation-maximization algorithm), planning (using decision networks) and perception (using dynamic Bayesian networks). Probabilistic algorithms can also be used for filtering, prediction, smoothing and finding explanations for streams of data, helping perception systems to analyze processes that occur over time (e.g., hidden Markov models or Kalman filters). Compared with symbolic logic, formal Bayesian inference is computationally expensive. For inference to be tractable, most observations must be conditionally independent of one another. Complicated graphs with diamonds or other "loops" (undirected cycles) can require a sophisticated method such as Markov chain Monte Carlo, which spreads an ensemble of random walkers throughout the Bayesian network and attempts to converge to an assessment of the conditional probabilities. Bayesian networks are used on Xbox Live to rate and match players; wins and losses are "evidence" of how good a player is. AdSenseuses a Bayesian network with over 300 million edges to learn which ads to serve.

A key concept from the science of economics is "utility": a measure of how valuable something is to an intelligent agent. Precise mathematical tools have been developed that analyze how an agent can make choices and plan, using decision theory, decision analysis, and information value theory. These tools include models such as Markov decision processes, decision networks, game theory and mechanism design.

The simplest AI applications can be divided into two types: classifiers ("if shiny then diamond") and controllers ("if shiny then pick up"). Controllers do, however, also classify conditions before inferring actions, and therefore classification forms a central part of many AI systems. Classifiers are functions that use pattern matching to determine a closest match. They can be tuned according to examples, making them very attractive for use in AI. These examples are known as observations or patterns. In supervised learning, each pattern belongs to a certain predefined class. A class can be seen as a decision that has to be made. All the observations combined with their class labels are known as a data set. When a new observation is received, that observation is classified based on previous experience.

A classifier can be trained in various ways; there are many statistical and machine learning approaches. The decision tree is perhaps the most widely used machine learning algorithm. Other widely used classifiers are the neural network, k-nearest neighbor algorithm, kernel methods such as the support vector machine (SVM), Gaussian mixture model, and the extremely popular naive

Bayes classifier. Classifier performance depends greatly on the characteristics of the data to be classified, such as the dataset size, distribution of samples across classes, the dimensionality, and the level of noise. Model-based classifiers perform well if the assumed model is an extremely good fit for the actual data. Otherwise, if no matching model is available, and if accuracy (rather than speed or scalability) is the sole concern, conventional wisdom is that discriminative classifiers (especially SVM) tend to be more accurate than model-based classifiers such as "naive Bayes" on most practical data sets.



A neural network is an interconnected group of nodes, akin to the vast network of neurons in the human brain.

Neural networks were inspired by the architecture of neurons in the human brain. A simple "neuron" N accepts input from other neurons, each of which, when activated (or "fired"), cast a weighted "vote" for or against whether neuron N should itself activate.

Learning requires an algorithm to adjust these weights based on the training data; one simple algorithm (dubbed "fire together, wire together") is to increase the weight between two connected neurons when the activation of one triggers the successful activation of another. The neural network forms "concepts" that are distributed among a subnetwork of shared neurons that tend to fire together; a concept meaning "leg" might be coupled with a subnetwork meaning "foot" that includes the sound for "foot". Neurons have a continuous spectrum of activation; in addition, neurons can process inputs in a nonlinear way rather than weighing straightforward votes. Modern neural networks can learn both continuous functions and, surprisingly, digital logical operations. Neural networks' early successes included predicting the stock market and (in 1995) a mostly self-driving car. In the 2010s, advances in neural networks using deep learning thrust AI into widespread public consciousness and contributed to an enormous upshift in corporate AI spending; for example, AI-related M&A in 2017 was over 25 times as large as in 2015.

The study of non-learning artificial neural networks began in the decade before the field of AI research was founded, in the work of Walter Pitts and Warren Mc Cullouch. Frank Rosen blattinvented the perceptron, a learning network with a single layer, similar to the old concept of linear regression. Early pioneers also include Alexey Grigorevich Ivakhnenko, Teuvo Kohonen, Stephen Grossberg, Kunihiko Fukushima, Christoph von der Malsburg, David Willshaw, Shun-Ichi Amari, Bernard Widrow, John Hopfield, Eduardo R. Caianiello, and others

The main categories of networks are acyclic or feedforward neural networks (where the signal passes in only one direction) and recurrent neural networks (which allow feedback and short-term memories of previous input events). Among the most popular feedforward networks are perceptrons, multi-layer perceptrons and radial basis networks. Neural networks can be applied to the problem of intelligent control (for robotics) or learning, using such techniques as Hebbian learning ("fire together, wire together"), GMDH or competitive learning.

Today, neural networks are often trained by the backpropagation algorithm, which had been around since 1970 as the reverse mode of automatic differentiation published by Seppo Linnainmaa, and was introduced to neural networks by Paul Werbos.

Hierarchical temporal memory is an approach that models some of the structural and algorithmic properties of the neocortex.

To summarize, most neural networks use some form of gradient descent on a hand-created neural topology. However, some research groups, such as Uber, argue that simple neuroevolution to mutate new neural network topologies and weights may be competitive with sophisticated gradient descent approaches. One advantage of neuroevolution is that it may be less prone to get caught in "dead ends"

Deep learning is any artificial neural network that can learn a long chain of causal links For example, a feedforward network with six hidden layers can learn a seven-link causal chain (six hidden layers + output layer) and has a "credit assignment path" (CAP) depth of seven. Many deep learning systems need to be able to learn chains ten or more causal links in length. Deep learning has transformed many important subfields of artificial intelligence including computer vision, speech recognition, natural language processing and others.

According to one overview, the expression "Deep Learning" was introduced to the machine learning community by Rina Dechter in 1986 and gained traction after Igor Aizenberg and colleagues introduced it to artificial neural networks in 2000. The first functional Deep Learning networks were published by Alexey Grigorevich Ivakhnenko and V. G. Lapa in 1965. These networks are trained one layer at a time. Ivakhnenko's 1971 paper describes the learning of a deep feedforward multilayer perceptron with eight layers, already much deeper than many later networks. In 2006, a publication by Geoffrey Hinton and Ruslan Salakhutdinov introduced another way of pre-training many-layered feedforward neural networks (FNNs) one layer at a time, treating each layer in turn as an unsupervised restricted Boltzmann machine, then using supervised backpropagation for fine-tuning Similar to shallow artificial neural networks, deep neural networks can model complex non-linear relationships. Over the last few years, advances in both machine learning algorithms and computer hardware have led to more efficient methods for training deep neural networks that contain many layers of non-linear hidden units and a very large output layer.

Deep learning often uses convolutional neural networks (CNNs), whose origins can be traced back to the Neocognitron introduced by Kunihiko Fukushima in 1980. In 1989, Yann LeCun and colleagues applied backpropagation to such an architecture. In the early 2000s, in an industrial application CNNs already processed an estimated 10% to 20% of all the checks written in the US. Since 2011, fast implementations of CNNs on GPUs have won many visual pattern recognition competitions.

CNNs with 12 convolutional layers were used in conjunction with reinforcement learning by Deepmind's "AlphaGo Lee", the program that beat a top Go champion in 2016.

Early on, deep learning was also applied to sequence learning with recurrent neural networks (RNNs) which are in theory Turing complete and can run arbitrary programs to process arbitrary sequences of inputs. The depth of an RNN is unlimited and depends on the length of its input sequence; thus, an RNN is an example of deep learning. RNNs can be trained by gradient descent but suffer from the vanishing gradient problem. In 1992, it was shown that unsupervised pre-training of a stack of recurrent neural networks can speed up subsequent supervised learning of deep sequential problems.

Numerous researchers now use variants of a deep learning recurrent NN called the long short-term memory (LSTM) network published by Hochreiter & Schmidhuber in 1997. LSTM is often trained by Connectionist Temporal Classification (CTC). At Google, Microsoft and Baidu this approach has revolutionized speech recognition. For example, in 2015, Google's speech recognition experienced a dramatic performance jump of 49% through CTC-trained LSTM, which is now available through Google Voice to billions of smartphone users. Google also used LSTM to improve machine translation, Language Modeling and Multilingual Language Processing. LSTM combined with CNNs also improved automatic image captioning and a plethora of other applications.

AI, like electricity or the steam engine, is a general purpose technology. There is no consensus on how to characterize which tasks AI tends to excel at. While projects such as AlphaZero have succeeded in generating their own knowledge from scratch, many other machine learning projects require large training datasets. Researcher Andrew Ng has suggested, as a "highly imperfect rule of thumb", that "almost anything a typical human can do with less than one second of mental thought, we can probably now or in the near future automate using AI." Moravec's paradox suggests that AI lags humans at many tasks that the human brain has specifically evolved to perform well.

Games provide a well-publicized benchmark for assessing rates of progress. AlphaGo around 2016 brought the era of classical board-game benchmarks to a close. Games of imperfect knowledge provide new challenges to AI in the area of game theory. E-sports such as StarCraft continue to provide additional public benchmarks. There are many competitions and prizes, such as the Imagenet Challenge, to promote research in artificial intelligence. The most common areas of competition include general machine intelligence, conversational behavior, data-mining, robotic cars, and robot soccer as well as conventional games.

The "imitation game" (an interpretation of the 1950 Turing test that assesses whether a computer can imitate a human) is nowadays considered too exploitable to be a meaningful benchmark. A derivative of the Turing test is the Completely Automated Public Turing test to tell Computers and Humans Apart (CAPTCHA). As the name implies, this helps to determine that a user is an actual person and not a computer posing as a human. In contrast to the standard Turing test, CAPTCHA is administered by a machine and targeted to a human as opposed to being administered by a human and targeted to a machine. A computer asks a user to complete a simple test then generates a grade for that test. Computers are unable to solve the problem, so correct solutions are deemed to be the result of a person taking the test. A common type of CAPTCHA is the test that requires the typing of distorted letters, numbers or symbols that appear in an image undecipherable by a computer.

Proposed "universal intelligence" tests aim to compare how well machines, humans, and even non-human animals perform on problem sets that are generic as possible. At an extreme, the test suite can contain every possible problem, weighted by Kolmogorov complexity; unfortunately, these problem sets tend to be dominated by impoverished pattern-matching exercises where a tuned AI can easily exceed human performance levels.

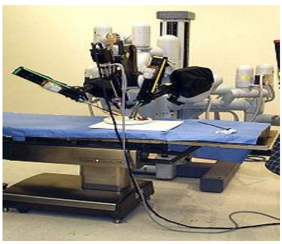
An automated online assistantproviding customer service on a web page – one of many very primitive applications of artificial intelligence

AI is relevant to any intellectual task. Modern artificial intelligence techniques are pervasive and are too numerous to list here. Frequently, when a technique reaches mainstream use, it is no longer considered artificial intelligence; this phenomenon is described as the AI effect.

High-profile examples of AI include autonomous vehicles (such as drones and self-driving cars), medical diagnosis, creating art (such as poetry), proving mathematical theorems, playing games (such as Chess or Go), search engines (such as Google search), online assistants (such as Siri), image recognition in photographs, spam filtering, predicting flight delays, prediction of judicial decisions, targeting online advertisements, and energy storage

With social media sites overtaking TV as a source for news for young people and news organizations increasingly reliant on social media platforms for generating distribution, major publishers now use artificial intelligence (AI) technology to post stories more effectively and generate higher volumes of traffic.

AI can also produce Deepfakes, a content-altering technology. ZDNet reports, "It presents something that did not actually occur," Though 88% of Americans believe Deepfakes can cause more harm than good, only 47% of them believe they can be targeted. The boom of election year also opens public discourse to threats of videos of falsified politician media.



A patient-side surgical arm of Da Vinci Surgical System

AI in healthcare is often used for classification, whether to automate initial evaluation of a CT scan or EKG or to identify high risk patients for population health. The breadth of applications is rapidly increasing. As an example, AI is being applied to the high cost problem of dosage issues—where findings suggested that AI could save $16 billion. In 2016, a ground breaking study in California found that a mathematical formula developed with the help of AI correctly determined the accurate dose of immunosuppressant drugs to give to organ patients.

X-ray of a hand, with automatic calculation of bone age by computer software

Artificial intelligence is assisting doctors. According to Bloomberg Technology, Microsoft has developed AI to help doctors find the right treatments for cancer. There is a great amount of research and drugs developed relating to cancer. In detail, there are more than 800 medicines and vaccines to treat cancer. This negatively affects the doctors, because there are too many options to choose from, making it more difficult to choose the right drugs for the patients. Microsoft is working on a project to develop a machine called "Hanover". Its goal is to memorize all the papers necessary to cancer and help predict which combinations of drugs will be most effective for each patient. One project that is being worked on at the moment is fighting myeloid leukemia, a fatal cancer where the treatment has not improved in decades. Another study was reported to have found that artificial intelligence was as good as trained doctors in identifying skin cancers. Another study is using artificial intelligence to try to monitor multiple high-risk patients, and this is done by asking each patient numerous questions based on data acquired from live doctor to patient interactions. One study was done with transfer learning, the machine performed a diagnosis similarly to a well-trained ophthalmologist, and could generate a decision within 30 seconds on whether or not the patient should be referred for treatment, with more than 95% accuracy.

According to CNN, a recent study by surgeons at the Children's National Medical Center in Washington successfully demonstrated surgery with an autonomous robot. The team supervised the robot while it performed soft-tissue surgery, stitching together a pig's bowel during open surgery, and doing so better than a human surgeon, the team claimed. IBM has created its own artificial intelligence computer, the IBM Watson, which has beaten human intelligence (at some levels). Watson has struggled to achieve success and adoption in healthcare.

Advancements in AI have contributed to the growth of the automotive industry through the creation and evolution of self-driving vehicles. As of 2016, there are over 30 companies utilizing AI into the creation of self-driving cars. A few companies involved with AI include Tesla, Google, and Apple.

Many components contribute to the functioning of self-driving cars. These vehicles incorporate systems such as braking, lane changing, collision prevention, navigation and mapping. Together, these systems, as well as high performance computers, are integrated into one complex vehicle.

Recent developments in autonomous automobiles have made the innovation of self-driving trucks possible, though they are still in the testing phase. The UK government has passed legislation to begin testing of self-driving truck platoons in 2018. Self-driving truck platoons are a fleet of self-driving trucks following the lead of one non-self-driving truck, so the truck platoons aren't entirely autonomous yet. Meanwhile, the Daimler, a German automobile corporation, is testing the Freightliner Inspiration which is a semi-autonomous truck that will only be used on the highway.

One main factor that influences the ability for a driver-less automobile to function is mapping. In general, the vehicle would be pre-programmed with a map of the area being driven. This map would include data on the approximations of street light and curb heights in order for the vehicle to be aware of its surroundings. However, Google has been working on an algorithm with the purpose of eliminating the need for pre-programmed maps and instead, creating a device that would be able to adjust to a variety of new surroundings. Some self-driving cars are not equipped with steering wheels or brake pedals, so there has also been research focused on creating an algorithm that is capable of maintaining a safe environment for the passengers in the vehicle through awareness of speed and driving conditions.

Another factor that is influencing the ability for a driver-less automobile is the safety of the passenger. To make a driver-less automobile, engineers must program it to handle high-risk situations. These situations could include a head-on collision with pedestrians. The car's main goal should be to make a decision that would avoid hitting the pedestrians and saving the passengers in the car. But there is a possibility the car would need to make a decision that would put someone in danger. In other words, the car would need to decide to save the pedestrians or the passengers. The programming of the car in these situations is crucial to a successful driver-less automobile.

Financial institutions have long used artificial neural network systems to detect charges or claims outside of the norm, flagging these for human investigation. The use of AI in banking can be traced back to 1987 when Security Pacific National Bank in US set-up a Fraud Prevention Task force to counter the unauthorized use of debit cards Programs like Kasisto and Moneystream are using AI in financial services.

Banks use artificial intelligence systems today to organize operations, maintain book-keeping, invest in stocks, and manage properties. AI can react to changes overnight or when business is not taking place. In August 2001, robots beat humans in a simulated financial trading competition. AI has also reduced fraud and financial crimes by monitoring behavioral patterns of users for any abnormal changes or anomalies.

AI is also being used by corporations. Whereas AI CEO's are still 30 years away, robotic process automation (RPA) is already being used today in corporate finance. RPA uses artificial intelligence to train and teach software robots to process transactions, monitor compliance and audit processes automatically.

The use of AI machines in the market in applications such as online trading and decision making has changed major economic theories. For example, AI based buying and selling platforms have changed the law of supply and demand in that it is now possible to easily estimate individualized demand and supply curves and thus individualized pricing. Furthermore, AI machines reduce information asymmetry in the market and thus making markets more efficient while reducing the volume of trades

Furthermore, AI in the markets limits the consequences of behavior in the markets again making markets more efficient Other theories where AI has had impact include in rational choice, rational expectations, game theory, Lewis turning point, portfolio optimization and counterfactual thinking. In August 2019, the AICPA introduced AI training course for accounting professionals.

Artificial intelligence paired with facial recognition systems may be used for mass surveillance. This is already the case in some parts of China. An artificial intelligence has also competed in the Tama City mayoral elections in 2018.

In 2019, the tech city of Bengaluru in India is set to deploy AI managed traffic signal systems across the 387 traffic signals in the city. This system will involve use of cameras to ascertain traffic density and accordingly calculate the time needed to clear the traffic volume which will determine the signal duration for vehicular traffic across streets.

Artificial intelligence (AI) is becoming a mainstay component of law-related professions. In some circumstances, this analytics-crunching technology is using algorithms and machine learning to do work that was previously done by entry-level lawyers.

In Electronic Discovery (eDiscovery), the industry has been focused on machine learning (predictive coding/technology assisted review), which is a subset of AI. To add to the soup of applications, Natural Language Processing (NLP) and Automated Speech Recognition (ASR) are also in vogue in the industry.

In video games, artificial intelligence is routinely used to generate dynamic purposeful behavior in non-player characters (NPCs). In addition, well-understood AI techniques are routinely used for pathfinding. Some researchers consider NPC AI in games to be a "solved problem" for most production tasks. Games with more atypical AI include the AI director of Left 4 Dead (2008) and the neuroevolutionary training of platoons in Supreme Commander 2 (2010).

The main military applications of Artificial Intelligence and Machine Learning are to enhance C2, Communications, Sensors, Integration and Interoperability. Artificial Intelligence technologies enables coordination of sensors and effectors, threat detection and identification, marking of enemy positions, target acquisition, coordination and deconfliction of distributed Join Fires between networked combat vehicles and tanks also inside Manned and Unmanned Teams (MUM-T).

Worldwide annual military spending on robotics rose from US$5.1 billion in 2010 to US$7.5 billion in 2015. Military drones capable of autonomous action are widely considered a useful asset. Many artificial intelligence researchers seek to distance themselves from military applications of AI.

In the hospitality industry, Artificial Intelligence based solutions are used to reduce staff load and increase efficiency by cutting repetitive tasks frequency, trends analysis, guest interaction, and customer needs prediction. Hotel services backed by Artificial Intelligence are represented in the form of a chatbot, application, virtual voice assistant and service robots.

For financial statements audit, AI makes continuous audit possible. AI tools could analyze many sets of different information immediately. The potential benefit would be the overall audit risk will be reduced, the level of assurance will be increased and the time duration of audit will be reduced.

It is possible to use AI to predict or generalize the behavior of customers from their digital footprints in order to target them with personalized promotions or build customer personas automatically. A documented case reports that online gambling companies were using AI to improve customer targeting.

Moreover, the application of Personality computing AI models can help reducing the cost of advertising campaigns by adding psychological targeting to more traditional sociodemographic or behavioral targeting.

Artificial Intelligence has inspired numerous creative applications including its usage to produce visual art.

The exhibition "Thinking Machines: Art and Design in the Computer Age, 1959–1989" at MoMA provides a good overview of the historical applications of AI for art, architecture, and design. Recent exhibitions showcasing the usage of AI to produce art include the Google-sponsored benefit and auction at the Gray Area Foundation in San Francisco, where artists experimented with the Deep Dream algorithm and the exhibition "Unhuman: Art in the Age of AI," which took place in Los Angeles and Frankfurt in the fall of 2017.

In the spring of 2018, the Association of Computing Machinery dedicated a special magazine issue to the subject of computers and art highlighting the role of machine learning in the arts. The Austrian Ars Electronica and Museum of Applied Arts, Vienna opened exhibitions on AI in 2019. The Ars Electronica's 2019 festival "Out of the box" extensively thematized the role of arts for a sustainable societal transformation with AI.

There are three philosophical questions related to AI:

1. Is artificial general intelligence possible? Can a machine solve any problem that a human being can solve using intelligence? Or are there hard limits to what a machine can accomplish?

2. Are intelligent machines dangerous? How can we ensure that machines behave ethically and that they are used ethically?

3. Can a machine have a mind, consciousness and mental states in exactly the same sense that human beings do? Can a machine be sentient, and thus deserve certain rights? Can a machine intentionally cause harm?

Can a machine be intelligent? Can it "think"?

Alan Turing's "polite convention"

We need not decide if a machine can "think"; we need only decide if a machine can act as intelligently as a human being.

This approach to the philosophical problems associated with artificial intelligence forms the basis of the Turing test.

The Dartmouth proposal

"Every aspect of learning or any other feature of intelligence can be so precisely described that a machine can be made to simulate it."

This conjecture was printed in the proposal for the Dartmouth Conference of 1956.

Newell and Simon's physical symbol system hypothesis

"A physical symbol system has the necessary and sufficient means of general intelligent action." Newell and Simon argue that intelligence consists of formal operations on symbols. Hubert

Dreyfus argued that, on the contrary, human expertise depends on unconscious instinct rather than conscious symbol manipulation and on having a "feel" for the situation rather than explicit symbolic knowledge. (See Dreyfus' critique of AI.)

Gödelian arguments

Gödel himself John Lucas (in 1961) and Roger Penrose (in a more detailed argument from 1989 onwards) made highly technical arguments that human mathematicians can consistently see the truth of their own "Gödel statements" and therefore have computational abilities beyond that of mechanical Turing machines. However, some people do not agree with the "Gödelian arguments".

The artificial brain argument

The brain can be simulated by machines and because brains are intelligent, simulated brains must also be intelligent; thus machines can be intelligent. Hans Moravec, Ray Kurzweil and others have argued that it is technologically feasible to copy the brain directly into hardware and software and that such a simulation will be essentially identical to the original.

The AI effect

Machines are already intelligent, but observers have failed to recognize it. When Deep Blue beat Garry Kasparov in chess, the machine was acting intelligently. However, onlookers commonly discount the behavior of an artificial intelligence program by arguing that it is not "real" intelligence after all; thus "real" intelligence is whatever intelligent behavior people can do that machines still cannot. This is known as the AI Effect: "AI is whatever hasn't been done yet."

Potential harm

Widespread use of artificial intelligence could have unintended consequences that are dangerous or undesirable. Scientists from the Future of Life Institute, among others, described some short-term research goals to see how AI influences the economy, the laws and ethics that are involved with AI and how to minimize AI security risks. In the long-term, the scientists have proposed to continue optimizing function while minimizing possible security risks that come along with new technologies.

The potential negative effects of AI and automation are a major issue for Andrew Yang's presidential campaign. Irakli Beridze, Head of the Centre for Artificial Intelligence and Robotics at UNICRI, United Nations, has expressed that "I think the dangerous applications for AI, from my point of view, would be criminals or large terrorist organizations using it to disrupt large processes or simply do pure harm. Terrorists could cause harm] via digital warfare, or it could be a combination of robotics, drones, with AI and other things as well that could be really dangerous. And, of course, other risks come from things like job losses. If we have massive numbers of people losing jobs and don’t find a solution, it will be extremely dangerous. Things like lethal autonomous weapons systems should be properly governed — otherwise there’s massive potential of misuse."

Physicist Stephen Hawking, Microsoft founder Bill Gates, and SpaceX founder Elon Musk have expressed concerns about the possibility that AI could evolve to the point that humans could not control it, with Hawking theorizing that this could "spell the end of the human race".

The development of full artificial intelligence could spell the end of the human race. Once humans develop artificial intelligence, it will take off on its own and redesign itself at an ever-increasing rate. Humans, who are limited by slow biological evolution, couldn't compete and would be superseded.

In his book Superintelligence, philosopher Nick Bostrom provides an argument that artificial intelligence will pose a threat to humankind. He argues that sufficiently intelligent AI, if it chooses actions based on achieving some goal, will exhibit convergent behavior such as acquiring resources or protecting itself from being shut down. If this AI's goals do not fully reflect humanity's—one example is an AI told to compute as many digits of pi as possible—it might harm humanity in order to acquire more resources or prevent itself from being shut down, ultimately to better achieve its goal. Bostrom also emphasizes the difficulty of fully conveying humanity's values to an advanced AI. He uses the hypothetical example of giving an AI the goal to make humans smile to illustrate a misguided attempt. If the AI in that scenario were to become superintelligent, Bostrom argues, it may resort to methods that most humans would find horrifying, such as inserting "electrodes into the facial muscles of humans to cause constant, beaming grins" because that would be an efficient way to achieve its goal of making humans smile. In his book Human Compatible, AI researcher Stuart J. Russell echoes some of Bostrom's concerns while also proposing an approach to developing provably beneficial machines focused on uncertainty and deference to humans, possibly involving inverse reinforcement learning

Concern over risk from artificial intelligence has led to some high-profile donations and investments. A group of prominent tech titans including Peter Thiel, Amazon Web Services and Musk have committed $1 billion to OpenAI, a nonprofit company aimed at championing responsible AI development. The opinion of experts within the field of artificial intelligence is mixed, with sizable fractions both concerned and unconcerned by risk from eventual superhumanly-capable AI. Other technology industry leaders believe that artificial intelligence is helpful in its current form and will continue to assist humans. Oracle CEO Mark Hurd has stated that AI "will actually create more jobs, not less jobs" as humans will be needed to manage AI systems. Facebook CEO Mark Zuckerberg believes AI will "unlock a huge amount of positive things," such as curing disease and increasing the safety of autonomous cars. In January 2015, Musk donated $10 million to the Future of Life Institute to fund research on understanding AI decision making. The goal of the institute is to "grow wisdom with which we manage" the growing power of technology. Musk also funds companies developing artificial intelligence such as DeepMind and Vicarious to "just keep an eye on what's going on with artificial intelligence. I think there is potentially a dangerous outcome there."

For the danger of uncontrolled advanced AI to be realized, the hypothetical AI would have to overpower or out-think all of humanity, which a minority of experts argue is a possibility far enough in the future to not be worth researching Other counterarguments revolve around humans being either intrinsically or convergently valuable from the perspective of an artificial intelligence.

Joseph Weizenbaum wrote that AI applications cannot, by definition, successfully simulate genuine human empathy and that the use of AI technology in fields such as customer service or psychotherapy was deeply misguided. Weizenbaum was also bothered that AI researchers (and some philosophers) were willing to view the human mind as nothing more than a computer program (a position now known as computationalism). To Weizenbaum these points suggest that AI research devalues human life.

One concern is that AI programs may be programmed to be biased against certain groups, such as women and minorities, because most of the developers are wealthy Caucasian men. Support for artificial intelligence is higher among men (with 47% approving) than women (35% approving).

Algorithms have a host of applications in today's legal system already, assisting officials ranging from judges to parole officers and public defenders in gauging the predicted likelihood of recidivism of defendants. COMPAS (an acronym for Correctional Offender Management Profiling for Alternative Sanctions) counts among the most widely utilized commercially available solutions. It has been suggested that COMPAS assigns an exceptionally elevated risk of recidivism to black defendants while, conversely, ascribing low risk estimate to white defendants significantly more often than statistically expected.

The relationship between automation and employment is complicated. While automation eliminates old jobs, it also creates new jobs through micro-economic and macro-economic effects. Unlike previous waves of automation, many middle-class jobs may be eliminated by artificial intelligence; The Economist states that "the worry that AI could do to white-collar jobs what steam power did to blue-collar ones during the Industrial Revolution" is "worth taking seriously". Subjective estimates of the risk vary widely; for example, Michael Osborne and Carl Benedikt Frey estimate 47% of U.S. jobs are at "high risk" of potential automation, while an OECD report classifies only 9% of U.S. jobs as "high risk". Jobs at extreme risk range from paralegals to fast food cooks, while job demand is likely to increase for care-related professions ranging from personal healthcare to the clergy. Author Martin Ford and others go further and argue that many jobs are routine, repetitive and (to an AI) predictable; Ford warns that these jobs may be automated in the next couple of decades, and that many of the new jobs may not be "accessible to people with average capability", even with retraining. Economists point out that in the past technology has tended to increase rather than reduce total employment, but acknowledge that "we're in uncharted territory" with AI.

Currently, 50+ countries are researching battlefield robots, including the United States, China, Russia, and the United Kingdom. Many people concerned about risk from superintelligent AI also want to limit the use of artificial soldiers and drones.

Machines with intelligence have the potential to use their intelligence to prevent harm and minimize the risks; they may have the ability to use ethical reasoning to better choose their actions in the world. Research in this area includes machine ethics, artificial moral agents, friendly AI and discussion towards building a human rights framework is also in talks.

Wendell Wallach introduced the concept of artificial moral agents (AMA) in his book Moral Machines For Wallach, AMAs have become a part of the research landscape of artificial intelligence as guided by its two central questions which he identifies as "Does Humanity Want Computers Making Moral Decisions"and "Can (Ro)bots Really Be Moral".For Wallach the question is not centered on the issue of whether machines can demonstrate the equivalent of moral behavior in contrast to the constraints which society may place on the development of AMAs.

The field of machine ethics is concerned with giving machines ethical principles, or a procedure for discovering a way to resolve the ethical dilemmas they might encounter, enabling them to function in an ethically responsible manner through their own ethical decision making. The field was delineated in the AAAI Fall 2005 Symposium on Machine Ethics: "Past research concerning the relationship between technology and ethics has largely focused on responsible and irresponsible use of technology by human beings, with a few people being interested in how human beings ought to treat machines. In all cases, only human beings have engaged in ethical reasoning. The time has come for adding an ethical dimension to at least some machines. Recognition of the ethical ramifications of behavior involving machines, as well as recent and potential developments in machine autonomy, necessitate this. In contrast to computer hacking, software property issues, privacy issues and other topics normally ascribed to computer ethics, machine ethics is concerned with the behavior of machines towards human users and other machines. Research in machine ethics is key to alleviating concerns with autonomous systems—it could be argued that the notion of autonomous machines without such a dimension is at the root of all fear concerning machine intelligence. Further, investigation of machine ethics could enable the discovery of problems with current ethical theories, advancing our thinking about Ethics. Machine ethics is sometimes referred to as machine morality, computational ethics or computational morality. A variety of perspectives of this nascent field can be found in the collected edition "Machine Ethics" that stems from the AAAI Fall 2005 Symposium on Machine Ethics.

Political scientist Charles T. Rubin believes that AI can be neither designed nor guaranteed to be benevolent. He argues that "any sufficiently advanced benevolence may be indistinguishable from malevolence." Humans should not assume machines or robots would treat us favorably because there is no a priori reason to believe that they would be sympathetic to our system of morality, which has evolved along with our particular biology (which AIs would not share). Hyper-intelligent software may not necessarily decide to support the continued existence of humanity and would be extremely difficult to stop. This topic has also recently begun to be discussed in academic publications as a real source of risks to civilization, humans, and planet Earth.

One proposal to deal with this is to ensure that the first generally intelligent AI is 'Friendly AI' and will be able to control subsequently developed AIs. Some question whether this kind of check could actually remain in place.

Leading AI researcher Rodney Brooks writes, "I think it is a mistake to be worrying about us developing malevolent AI anytime in the next few hundred years. I think the worry stems from a fundamental error in not distinguishing the difference between the very real recent advances in a particular aspect of AI, and the enormity and complexity of building sentient volitional intelligence."

If an AI system replicates all key aspects of human intelligence, will that system also be sentient—will it have a mind which has conscious experiences? This question is closely related to the philosophical problem as to the nature of human consciousness, generally referred to as the hard problem of consciousness.

David Chalmers identified two problems in understanding the mind, which he named the "hard" and "easy" problems of consciousness. The easy problem is understanding how the brain processes signals, makes plans and controls behavior. The hard problem is explaining how this feels or why it should feel like anything at all. Human information processing is easy to explain, however human subjective experience is difficult to explain.

For example, consider what happens when a person is shown a color swatch and identifies it, saying "it's red". The easy problem only requires understanding the machinery in the brain that makes it possible for a person to know that the color swatch is red. The hard problem is that people also know something else—they also know what red looks like. (Consider that a person born blind can know that something is red without knowing what red looks like.) Everyone knows subjective experience exists, because they do it every day (e.g., all sighted people know what red looks like). The hard problem is explaining how the brain creates it, why it exists, and how it is different from knowledge and other aspects of the brain.

Computationalism is the position in the philosophy of mind that the human mind or the human brain (or both) is an information processing system and that thinking is a form of computing. Computationalism argues that the relationship between mind and body is similar or identical to the relationship between software and hardware and thus may be a solution to the mind-body problem. This philosophical position was inspired by the work of AI researchers and cognitive scientists in the 1960s and was originally proposed by philosophers Jerry Fodor and Hilary Putnam.

The philosophical position that John Searle has named "strong AI" states: "The appropriately programmed computer with the right inputs and outputs would thereby have a mind in exactly the same sense human beings have minds." Searle counters this assertion with his Chinese room argument, which asks us to look inside the computer and try to find where the "mind" might be.

If a machine can be created that has intelligence, could it also feel? If it can feel, does it have the same rights as a human? This issue, now known as "robot rights", is currently being considered by, for example, California's Institute for the Future, although many critics believe that the discussion is premature. Some critics of transhumanism argue that any hypothetical robot rights would lie on a spectrum with animal rights and human rights. The subject is profoundly discussed in the 2010 documentary film Plug & Pray, and many sci fi media such as Star Trek Next Generation, with the character of Commander Data, who fought being disassembled for research, and wanted to "become human", and the robotic holograms in Voyager.

Are there limits to how intelligent machines—or human-machine hybrids—can be? A superintelligence, hyperintelligence, or superhuman intelligence is a hypothetical agent that would possess intelligence far surpassing that of the brightest and most gifted human mind. Superintelligence may also refer to the form or degree of intelligence possessed by such an agent.

If research into Strong AI produced sufficiently intelligent software, it might be able to reprogram and improve itself. The improved software would be even better at improving itself, leading to recursive self-improvement. The new intelligence could thus increase exponentially and dramatically surpass humans. Science fiction writer Vernor Vinge named this scenario "singularity". Technological singularity is when accelerating progress in technologies will cause a runaway effect wherein artificial intelligence will exceed human intellectual capacity and control, thus radically changing or even ending civilization. Because the capabilities of such an intelligence may be impossible to comprehend, the technological singularity is an occurrence beyond which events are unpredictable or even unfathomable Ray Kurzweil has used Moore's law (which describes the relentless exponential improvement in digital technology) to calculate that desktop computers will have the same processing power as human brains by the year 2029, and predicts that the singularity will occur in 2045.

Robot designer Hans Moravec, cyberneticist Kevin Warwick and inventor Ray Kurzweil have predicted that humans and machines will merge in the future into cyborgs that are more capable and powerful than either. This idea, called transhumanism, has roots in Aldous Huxley and Robert Ettinger.

Edward Fredkin argues that "artificial intelligence is the next stage in evolution", an idea first proposed by Samuel Butler's "Darwin among the Machines" as far back as 1863, and expanded upon by George Dyson in his book of the same name in 1998.

The long-term economic effects of AI are uncertain. A survey of economists showed disagreement about whether the increasing use of robots and AI will cause a substantial increase in long-term unemployment, but they generally agree that it could be a net benefit, if productivity gains are redistributed.

The word "robot" itself was coined by Karel Čapek in his 1921 play R.U.R., the title standing for "Rossum's Universal Robots"

Thought-capable artificial beings appeared as storytelling devices since antiquity, and have been a persistent theme in science fiction.

A common trope in these works began with Mary Shelley's Frankenstein, where a human creation becomes a threat to its masters. This includes such works as Arthur C. Clarke's and Stanley Kubrick's 2001: A Space Odyssey (both 1968), with HAL 9000, the murderous computer in charge of the Discovery One spaceship, as well as The Terminator (1984) and The Matrix (1999). In contrast, the rare loyal robots such as Gort from The Day the Earth Stood Still (1951) and Bishop from Aliens (1986) are less prominent in popular culture.

Isaac Asimov introduced the Three Laws of Robotics in many books and stories, most notably the "Multivac" series about a super-intelligent computer of the same name. Asimov's laws are often brought up during lay discussions of machine ethics; while almost all artificial intelligence researchers are familiar with Asimov's laws through popular culture, they generally consider the laws useless for many reasons, one of which is their ambiguity.

Transhumanism (the merging of humans and machines) is explored in the manga Ghost in the Shell and the science-fiction series Dune. In the 1980s, artist Hajime Sorayama's Sexy Robots series were painted and published in Japan depicting the actual organic human form with lifelike muscular metallic skins and later "the Gynoids" book followed that was used by or influenced movie makers including George Lucas and other creatives. Sorayama never considered these organic robots to be real part of nature but always unnatural product of the human mind, a fantasy existing in the mind even when realized in actual form.

Several works use AI to force us to confront the fundamental question of what makes us human, showing us artificial beings that have the ability to feel, and thus to suffer. This appears in Karel Čapek's R.U.R., the films A.I. Artificial Intelligence and Ex Machina, as well as the novel Do Androids Dream of Electric Sheep?, by Philip K. Dick. Dick considers the idea that our understanding of human subjectivity is altered by technology created with artificial intelligence.

REFERENCES

1. Poole, Mackworth & Goebel 2008, p. 1, which provides the version that is used in this article. Note that they use the term "computational intelligence" as a synonym for artificial intelligence.

2. Russell & Norvig (2003) (who prefer the term "rational agent") and write "The whole-agent view is now widely accepted in the field" (Russell & Norvig 2003, p. 55).

A CALCULATOR

A calculator is a small hand-held computer that performs mathematical calculations. Some calculators even permit simple text editing and programming.

It is also a program on a computer that simulates a hand-held calculator. Calculator programs let you perform simple math calculations without leaving the computer. The Apple Macintosh comes with a calculator desk accessory. Likewise, Microsoft Windows includes a calculator accessory.

An electronic calculator is typically a portable electronic device used to perform calculations, ranging from basic arithmetic to complex mathematics.

The first solid-state electronic calculator was created in the early 1960s. Pocket-sized devices became available in the 1970s, especially after the Intel 4004, the first microprocessor, was developed by Intel for the Japanese calculator company Busicom. They later became used commonly within the petroleum industry (oil and gas).

Modern electronic calculators vary from cheap, give-away, credit-card-sized models to sturdy desktop models with built-in printers. They became popular in the mid-1970s as the incorporation of integrated circuits reduced their size and cost. By the end of that decade, prices had dropped to the point where a basic calculator was affordable to most and they became common in schools.

Computer operating systems as far back as early Unix have included interactive calculator programs such as dc and hoc, and calculator functions are included in almost all personal digital assistant (PDA) type devices, the exceptions being a few dedicated address book and dictionary devices.

In addition to general purpose calculators, there are those designed for specific markets. For example, there are scientific calculators which

include trigonometric and statistical calculations. Some calculators even have the ability to do computer algebra. Graphing calculators can be used to graph functions defined on the real line, or higher-dimensional Euclidean space. As of 2016, basic calculators cost little, but scientific and graphing models tend to cost more.

In 1986, calculators still represented an estimated 41% of the world's general-purpose hardware capacity to compute information. By 2007, this had diminished to less than 0.05%.

Input

Electronic calculators contain a keyboard with buttons for digits and arithmetical operations; some even contain "00" and "000" buttons to make larger or smaller numbers easier to enter. Most basic calculators assign only one digit or operation on each button; however, in more specific calculators, a button can perform multi-function working with key combinations.

Display output

Calculators usually have liquid-crystal displays (LCD) as output in place of historical light-emitting diode (LED) displays and vacuum fluorescent displays (VFD); details are provided in the section Technical improvements.

Large-sized figures are often used to improve readability; while using decimal separator (usually a point rather than a comma) instead of or in addition to vulgar fractions. Various symbols for function commands may also be shown on the display.

Fractions such as ⅓ are displayed as decimal approximations, for example rounded to 0.33333333. Also, some fractions (such as ⅐, which is 0.14285714285714; to 14 significant figures) can be difficult to recognize in decimal form; as a result, many scientific calculators are able to work in vulgar fractions or mixed numbers.

Memory

Calculators also have the ability to store numbers into computer memory.

Basic calculators usually store only one number at a time; more specific types are able to store many numbers represented in variables.

The variables can also be used for constructing formulas. Some models have the ability to extend memory capacity to store more numbers; the extended memory address is termed an array index.

Power source

Power sources of calculators are: batteries, solar cells or mains electricity (for old models), turning on with a switch or button.

Some models even have no turn-off button but they provide some way to put off (for example, leaving no operation for a moment, covering solar cell exposure, or closing their lid).

Crank-powered calculators were also common in the early computer era.

Key layout

The following keys are common to most pocket calculators. While the arrangement of the digits is standard, the positions of other keys vary from model to model; the illustration is an example.

Usual basic pocket calculator layout

MC	**MR**	**M−**	**M+**
C	±	**%**	√
7	**8**	**9**	÷
4	**5**	**6**	×
1	**2**	**3**	−
0	**.**	=	+

Calculator buttons and their meanings

MC or CM	**Memory Clear**
MR, RM, or MRC	**Memory Recall**
M−	**Memory Subtraction**

M+	**Memory Addition**
C or AC	**All Clear**
CE	**Clear (last) Entry; sometimes called CE/C: a first press clears the last entry (CE), a second press clears all (C)**
± or CHS	**Toggle positive/negative number aka CHange Sign**
%	**Percent**
÷	**Division**
×	**Multiplication**
−	**Subtraction**
+	**Addition**
.	**Decimal point**
√	**Square root**
=	**Result**

Internal workings

In general, a basic electronic calculator consists of the following components:[2]

- Power source (mains electricity, battery and/or solar cell)
- Keypad (input device) – consists of keys used to input numbers and function commands (addition, multiplication, square-root, etc.)
- Display panel (output device) – displays input numbers, commands and results. Liquid-crystal displays (LCDs), vacuum fluorescent displays (VFDs), and light-emitting diode (LED) displays use seven segments to represent each digit in a basic calculator. Advanced calculators may use dot matrix displays.
  - A printing calculator, in addition to a display panel, has a printing unit that prints results in ink onto a roll of paper, using a printing mechanism.
- Processor chip (microprocessor or central processing unit).

Processor chip's contents	
Unit	Function

Scanning (Polling) unit	When a calculator is powered on, it scans the keypad waiting to pick up an electrical signal when a key is pressed.
Encoder unit	Converts the numbers and functions into bina ry code.
X register and Y register	They are number stores where numbers are stored temporarily while doing calculations. All numbers go into the X register first; the number in the X register is shown on the display.
Flag register	The function for the calculation is stored here until the calculator needs it.
Permanent memory (RO M)	The instructions for in-built functions (arithmetic operations, square roots, percentages, trigonometry, etc.) are stored here in binary form.

	These instructions are programs, stored permanently, and cannot be erased.
User memory (RAM)	The store where numbers can be stored by the user. User memory contents can be changed or erased by the user.
Arithmetic logic unit (ALU)	The ALU executes all arithmetic and logic instructions, and provides the results in binary coded form.
Binary decoder unit	Converts binary code into decimal numbers which can be displayed on the display unit.

Clock rate of a processor chip refers to the frequency at which the central processing unit (CPU) is running. It is used as an indicator of the processor's speed, and is measured in clock cycles per second or the SI unit hertz (Hz). For basic calculators, the speed can vary from a few hundred hertz to the kilohertz range.

An office calculating machine with a paper printer

Example

A basic explanation as to how calculations are performed in a simple four-function calculator:

To perform the calculation 25 + 9, one presses keys in the following sequence on most calculators: 2 5 + 9 =.

- When 2 5 is entered, it is picked up by the scanning unit; the number 25 is encoded and sent to the X register;
- Next, when the + key is pressed, the "addition" instruction is also encoded and sent to the flag or the status register;
- The second number 9 is encoded and sent to the X register. This "pushes" (shifts) the first number out into the Y register;
- When the = key is pressed, a "message" (signal) from the flag or status register tells the permanent or non-volatile memory that the operation to be done is "addition";

• The numbers in the X and Y registers are then loaded into the ALU and the calculation is carried out following instructions from the permanent or non-volatile memory;

• The answer, 34 is sent (shifted) back to the X register. From there, it is converted by the binary decoder unit into a decimal number (usually binary-coded decimal), and then shown on the display panel.

Other functions are usually performed using repeated additions or subtractions.

Numeric representation

Most pocket calculators do all their calculations in BCD rather than a floating-point representation. BCD is common in electronic systems where a numeric value is to be displayed, especially in systems consisting solely of digital logic, and not containing a microprocessor. By employing BCD, the manipulation of numerical data for display can be greatly simplified by treating each digit as a separate single sub-circuit. This matches much more closely the physical reality of display hardware—a designer might choose to use a series of separate identical seven-segment displays to build a metering circuit, for example. If the numeric quantity were stored and manipulated as pure binary, interfacing to such a display would require complex circuitry. Therefore, in cases where the calculations are relatively simple, working throughout with BCD can lead to a simpler overall system than converting to and from binary.

The same argument applies when hardware of this type uses an embedded microcontroller or other small processor. Often, smaller code results when representing numbers internally in BCD format, since a conversion from or to binary representation can be expensive on such limited processors. For these applications, some small processors feature BCD arithmetic modes, which assist when writing routines that manipulate BCD quantities.

Where calculators have added functions (such as square root, or trigonometric functions), software algorithms are required to produce high precision results. Sometimes significant design effort is needed to fit all the desired functions in the limited memory space available in the calculator chip, with acceptable calculation time.

Calculators compared to computers

The fundamental difference between a calculator and computer is that a computer can be programmed in a way that allows the program to take different branches according to intermediate results, while calculators are pre-designed with specific functions (such as addition, multiplication, and logarithms) built in.

The distinction is not clear-cut: some devices classed as programmable calculators have programming functions, sometimes with support for programming languages (such as RPL or TI-BASIC).

For instance, instead of a hardware multiplier, a calculator might implement floating point mathematics with code in read-only memory (ROM), and compute trigonometric functions with the CORDIC algorithm because CORDIC does not require much multiplication. Bit serial logic designs are more common in calculators whereas bit parallel designs dominate general-purpose computers, because a bit serial design minimizes chip complexity, but takes many more clock cycles.

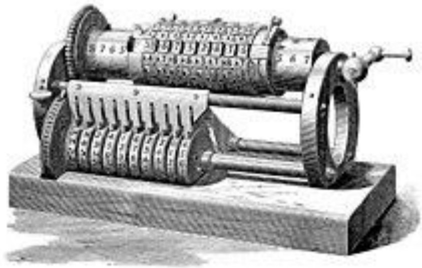
This distinction blurs with high-end calculators, which use processor chips associated with computer and embedded systems design, more so the Z80, MC68000, and ARM architectures, and some custom designs specialized for the calculator market.

Precursors to the electronic calculator

The first known tools used to aid arithmetic calculations were: bones (used to tally items), pebbles, and counting boards, and the abacus, known to have been used by Sumerians and Egyptians before 2000 BC. Except for the Antikythera mechanism (an "out of the time" astronomical device), development of computing tools arrived near the start of the 17th century: the geometric-military compass (by Galileo), logarithms and Napier bones (by Napier), and the slide rule (by Edmund Gunter).

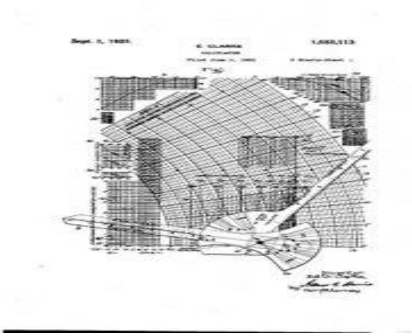
17th century mechanical calculators

In 1642, the Renaissance saw the invention of the mechanical calculator (by Wilhelm Schickard and several decades later Blaise Pascal), a device that was at times somewhat over-promoted as being able to perform all four arithmetic operations with minimal human intervention. Pascal's calculator could add and subtract two numbers directly and thus, if the tedium could be borne, multiply and divide by repetition. Schickard's machine, constructed several decades earlier, used a clever set of mechanised multiplication tables to ease the process of multiplication and division with the adding machine as a means of completing this operation. (Because they were different inventions with different aims a debate about whether Pascal or Schickard should be credited as the "inventor" of the adding machine (or calculating machine) is probably pointless. Schickard and Pascal were followed by Gottfried Leibniz who spent forty years designing a four-operation mechanical calculator, the stepped reckoner, inventing in the process his leibniz wheel, but who couldn't design a fully operational machine. There were also five unsuccessful attempts to design a calculating clock in the 17th century.



The Grant mechanical calculating machine, 1877

The 18th century saw the arrival of some notable improvements, first by Poleni with the first fully functional calculating clock and four-operation machine, but these machines were almost always one of the kind. Luigi Torchi invented the first direct multiplication machine in 1834: this was also the second key-driven machine in the world, following that of James White (1822). It was not until the 19th century and the Industrial Revolution that real developments began to occur. Although machines capable of performing all four arithmetic functions existed prior to the 19th century, the refinement of manufacturing and fabrication processes during the eve of the industrial revolution made large scale production of more compact and modern units possible. The Arithmometer, invented in 1820 as a four-operation mechanical calculator, was released to production in 1851 as an adding machine and became the first commercially successful unit; forty years later, by 1890, about 2,500 arithmometers had been sold plus a few hundreds more from two arithmometer clone makers (Burkhardt, Germany, 1878 and Layton, UK, 1883) and Felt and Tarrant, the only other competitor in true commercial production, had sold 100 comptometers.



Patent image of the Clarke graph-based calculator, 1921

It wasn't until 1902 that the familiar push-button user interface was developed, with the introduction of the Dalton Adding Machine, developed by James L. Dalton in the United States.

In 1921, Edith Clarke invented the "Clarke calculator", a simple graph-based calculator for solving line equations involving hyperbolic functions. This allowed electrical engineers to simplify calculations for inductance and capacitance in power transmission lines.

The Curta calculator was developed in 1948 and, although costly, became popular for its portability. This purely mechanical hand-held device could do addition, subtraction, multiplication and division. By the early 1970s electronic pocket calculators ended manufacture of mechanical calculators, although the Curta remains a popular collectable item.

Development of electronic calculators

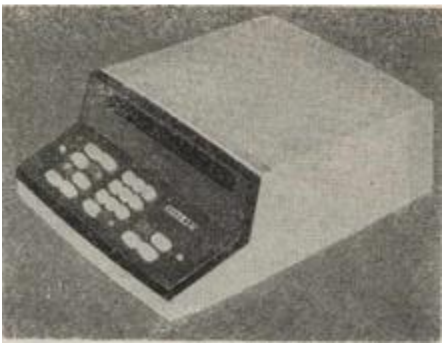
The first mainframe computers, using firstly vacuum tubes and later transistors in the logic circuits, appeared in the 1940s and 1950s. This technology was to provide a stepping stone to the development of electronic calculators.

The Casio Computer Company, in Japan, released the Model 14-A calculator in 1957, which was the world's first all-electric (relatively) compact calculator. It did not use electronic logic but was based on relay technology, and was built into a desk.

Early calculator light-emitting diode (LED) display from the 1970s (USSR)

In October 1961, the world's first all-electronic desktop calculator, the British Bell Punch/Sumlock Comptometer ANITA (A New Inspiration To Ari thmetic/Accounting) was announced. This machine used vacuum tubes, cold-cathode tubes and Dekatrons in its circuits, with 12 cold-cathode "Nixie" tubes for its display. Two models were displayed, the Mk VII for continental Europe and the Mk VIII for Britain and the rest of the world, both for delivery from early 1962. The Mk VII was a slightly earlier design with a more complicated mode of multiplication, and was soon dropped in favour of the simpler Mark VIII. The ANITA had a full keyboard, similar to mechanical comptometers of the time, a feature that was unique to it and the later Sharp CS-10A among electronic calculators. The ANITA weighed roughly 33 pounds (15 kg) due to its large tube system. Bell Punch had been producing key-driven mechanical calculators of the comptometer type under the names "Plus" and "Sumlock", and had realised in the mid-1950s that the future of calculators lay in electronics. They employed the young graduate Norbert Kitz, who had worked on the early British Pilot ACE computer project, to lead the development. The ANITA sold well since it was the only electronic desktop calculator available, and was silent and quick.

The tube technology of the ANITA was superseded in June 1963 by the U.S. manufactured Friden EC-130, which had an all-transistor design, a stack of four 13-digit numbers displayed on a 5-inch (13 cm) cathode ray tube (CRT), and introduced Reverse Polish Notation (RPN) to the calculator market for a price of $2200, which was about three times the cost of an electromechanical calculator of the time. Like Bell Punch, Friden was a manufacturer of mechanical calculators that had decided that the future lay in electronics. In 1964 more all-transistor electronic calculators were introduced: Sharp introduced the CS-10A, which weighed 25 kilograms (55 lb) and cost 500,000 yen ($4528), and Industria Macchine Elettroniche of Italy introduced the IME 84, to which several extra keyboard and display units could be connected so that several people could make use of it (but apparently not at the same time).



The Bulgarian ELKA 22 from 1967

There followed a series of electronic calculator models from these and other manufacturers, including Canon, Mathatronics, Olivetti, SCM (Smith-Corona-Marchant), Sony, Toshiba, and

Wang. The early calculators used hundreds of germanium transistors, which were cheaper than silicon transistors, on multiple circuit boards. Display types used were CRT, cold-cathode Nixie tubes, and filament lamps. Memory technology was usually based on the delay line memory or the magnetic core memory, though the Toshiba "Toscal" BC-1411 appears to have used an early form of dynamic RAM built from discrete components. Already there was a desire for smaller and less power-hungry machines.

Bulgaria's ELKA 6521, introduced in 1965, was developed by the Central Institute for Calculation Technologies and built at the Elektronika factory in Sofia. The name derives from ELektronen KAlkulator, and it weighed around 8 kg (18 lb). It is the first calculator in the world which includes the square root function. Later that same year were released the ELKA 22 (with a luminescent display) and the ELKA 25, with an in-built printer. Several other models were developed until the first pocket model, the ELKA 101, was released in 1974. The writing on it was in Roman script, and it was exported to western countries.

Programmable calculators

The Italian Programma 101, an early commercial programmable claculator produced by Olivetti in 1964

The first desktop programmable calculators were produced in the mid-1960s. They included the Mathatronics Mathatron (1964) and the Olivetti Programma 101 (late 1965) which were solid-state, desktop, printing, floating point, algebraic entry, programmable, stored-program electronic calculators. Both could be programmed by the end user and print out their results. The Programma 101 saw much wider distribution and had the added feature of offline storage of programs via magnetic cards.

Another early programmable desktop calculator (and maybe the first Japanese one) was the Casio (AL-1000) produced in 1967. It featured a nixie tubes display and had transistor electronics and ferrite core memory.

The Monroe Epic programmable calculator came on the market in 1967. A large, printing, desk-top unit, with an attached floor-standing logic tower, it could be programmed to perform many computer-like functions. However, the only branch instruction was an implied unconditional branch (GOTO) at the end of the operation stack, returning the program to its starting instruction. Thus, it was not possible to include any conditional branch (IF-THEN-ELSE) logic. During this era, the absence of the conditional branch was sometimes used to distinguish a programmable calculator from a computer.

The first Soviet programmable desktop calculator ISKRA 123, powered by the power grid, was released at the start of the 1970s.

1970s to mid-1980s

The electronic calculators of the mid-1960s were large and heavy desktop machines due to their use of hundreds of transistors on several circuit boards with a large power consumption that required an AC power supply. There were great efforts to put the logic required for a calculator into fewer and fewer integrated circuits (chips) and calculator electronics was one of the leading edges of semiconductor development. U.S. semiconductor manufacturers led the world in large scale integration (LSI) semiconductor development, squeezing more and more functions into individual integrated circuits. This led to alliances between Japanese calculator manufacturers and U.S. semiconductor companies: Canon Inc. with Texas Instruments, Hayakawa Electric (later renamed Sharp Corporation) with North-American Rockwell Microelectronics (later renamed Rockwell International), Busicom with Mostek and Intel, and General Instrument with Sanyo.

Pocket calculators

"Pocket calculator" redirects here. For the song, see Computer World.

By 1970, a calculator could be made using just a few chips of low power consumption, allowing portable models powered from rechargeable batteries. The first handheld calculator was a 1967 prototype called "Cal Tech", whose development was led by Jack Kilby at Texas Instruments in a research project to produce a portable calculator. It could add, multiply, subtract, and divide, and its output device was a paper tape. As a result of the "Cal-Tech" project, Texas Instruments was granted master patents on portable calculators.

The first comercially produced portable calculators appeared in Japan in 1970, and were soon marketed around the world. These included the Sanyo ICC-0081 "Mini Calculator", the Canon Pocketronic, and the Sharp QT-8B "micro Compet". The Canon Pocketronic was a development from the "Cal-Tech" project. It had no traditional display; numerical output was on thermal paper tape.

Sharp put in great efforts in size and power reduction and introduced in January 1971 the Sharp EL-8, also marketed as the Facit 1111, which was close to being a pocket calculator. It weighed 1.59 pounds (721 grams), had a vacuum fluorescent display, rechargeable NiCad batteries, and initially sold for US $395.

However, integrated circuit development efforts culminated in early 1971 with the introduction of the first "calculator on a chip", the MK6010 by Mostek, followed by Texas Instruments later in the year. Although these early hand-held calculators were very costly, these advances in electronics, together with developments in display technology (such as the vacuum fluorescent display, LED, and LCD), led within a few years to the cheap pocket calculator available to all.

In 1971 Pico Electronics. and General Instrument also introduced their first collaboration in ICs, a full single chip calculator IC for the Monroe Royal Digital III calculator. Pico was a spinout by five GI design engineers whose vision was to create single chip calculator ICs. Pico and GI went on to have significant success in the burgeoning handheld calculator market.

The first truly pocket-sized electronic calculator was the Busicom LE-120A "HANDY", which was marketed early in 1971. Made in Japan, this was also the first calculator to use an LED display, the first hand-held calculator to use a single integrated circuit (then proclaimed as a "calculator on a chip"), the Mostek MK6010, and the first electronic calculator to run off replaceable batteries. Using four AA-size cells the LE-120A measures 4.9 by 2.8 by 0.9 inches (124 mm × 71 mm × 23 mm).

The first European-made pocket-sized calculator, DB 800 is made in May 1971 by Digitron in Buje, Croatia (former Yugoslavia) with four functions and an eight-digit display and special characters for a negative number and a warning that the calculation has too many digits to display.

The first American-made pocket-sized calculator, the Bowmar 901B (popularly termed The Bowmar Brain), measuring 5.2 by 3.0 by 1.5 inches (132 mm × 76 mm × 38 mm), came out in the Autumn of 1971, with four functions and an eight-digit red LED display, for $240, while in August 1972 the four-function Sinclair Executive became the first slimline pocket calculator measuring 5.4 by 2.2 by 0.35 inches (137.2 mm × 55.9 mm × 8.9 mm) and weighing 2.5 ounces (71 g). It retailed for around £79 ($194 at the time). By the end of the decade, similar calculators were priced less than £5 ($6.67).

The first Soviet Union made pocket-sized calculator, the Elektronika B3-04 was developed by the end of 1973 and sold at the start of 1974.

One of the first low-cost calculators was the Sinclair Cambridge, launched in August 1973. It retailed for £29.95 ($39.93), or £5 ($6.67) less in kit form. The Sinclair calculators were successful because they were far cheaper than the competition; however, their design led to slow and inaccurate computations of transcendental functions.

Meanwhile, Hewlett-Packard (HP) had been developing a pocket calculator. Launched in early 1972, it was unlike the other basic four-function pocket calculators then available in that it was the first pocket calculator with scientific functions that could replace a slide rule. The $395 HP-35, along with nearly all later HP engineering calculators, used reverse Polish notation (RPN), also called postfix notation.

A calculation like "8 plus 5" is, using RPN, performed by pressing 8, Enter↑, 5, and +; instead of the algebraic infix notation: 8, +, 5, =. It had 35 buttons and was based on Mostek Mk6020 chip.

The first Soviet scientific pocket-sized calculator the "B3-18" was completed by the end of 1975.

In 1973, Texas Instruments (TI) introduced the SR-10, (SR signifying slide rule) an algebraic entry pocket calculator using scientific notation for $150. Shortly after the SR-11 featured an added key for entering Pi (π). It was followed the next year by the SR-50 which added log and trig functions to compete with the HP-35, and in 1977 the mass-marketed TI-30 line which is still produced.

In 1978 a new company, Calculated Industries arose which focused on specialized markets. Their first calculator, the Loan Arranger (1978) was a pocket calculator marketed to the Real Estate industry with preprogrammed functions to simplify the process of calculating payments and future values. In 1985, CI launched a calculator for the construction industry called the Construction Master which came preprogrammed with common construction calculations (such as angles, stairs, roofing math, pitch, rise, run, and feet-inch fraction conversions). This would be the first in a line of construction related calculators.

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Adler 81S pocket calculator with vacuum fluorescent display (VFD) from the mid-1970s.

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The Casio CM-602 Mini electronic calculator provided basic functions in the 1970s.

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The 1972 Sinclair Executive pocket calculator.

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The HP-35, the world's first scientific pocket calculator by Hewlett Packard (1972).

Programmable pocket calculators

The first programmable pocket calculator was the HP-65, in 1974; it had a capacity of 100 instructions, and could store and retrieve programs with a built-in magnetic card reader. Two years later the HP-25C introduced continuous memory, i.e., programs and data were retained in CMOS memory during power-off. In 1979, HP released the first alphanumeric, programmable, expandable calculator, the HP-41C. It could be expanded with random access memory (RAM, for memory) and read-only memory (ROM, for software) modules, and peripherals like bar code readers, microcassette and floppy disk drives, paper-roll thermal printers, and miscellaneous communication interfaces (RS-232, HP-IL, HP-IB).

The HP-65, the first programmable pocket calculator (1974)

The first Soviet pocket battery-powered programmable calculator, Elektronika B3-21, was developed by the end of 1976 and released at the start of 1977. The successor of B3-21, the Elektronika B3-34 wasn't backward compatible with B3-21, even if it kept the reverse Polish notation (RPN). Thus B3-34 defined a new command set, which later was used in a series of later programmable Soviet calculators. Despite very limited abilities (98 bytes of instruction memory and about 19 stack and addressable registers), people managed to write all kinds of programs for them, including adventure games and libraries of calculus-related functions for engineers. Hundreds, perhaps thousands, of programs were written for these machines, from practical scientific and business software, which were used in real-life offices and labs, to fun games for children. The Elektronika MK-52 calculator (using the extended B3-34 command set, and featuring internal EEPROM memory for storing programs and external interface for EEPROM cards and other periphery) was used in Soviet spacecraft program (for Soyuz TM-7 flight) as a backup of the board computer.

This series of calculators was also noted for a large number of highly counter-intuitive mysterious undocumented features, somewhat similar to "synthetic programming" of the American HP-41, which were exploited by applying normal arithmetic operations to error messages, jumping to nonexistent addresses and other methods. A number of respected monthly publications, including the popular science magazine Nauka i Zhizn (Наука и жизнь, Science and Life), featured special columns, dedicated to optimization methods for calculator programmers and updates on undocumented features for hackers, which grew into a whole esoteric science with many branches, named "yeggogology" ("еггогология"). The error messages on those calculators appear as a Russian word "YEGGOG" ("ЕГГОГ") which, unsurprisingly, is translated to "Error".

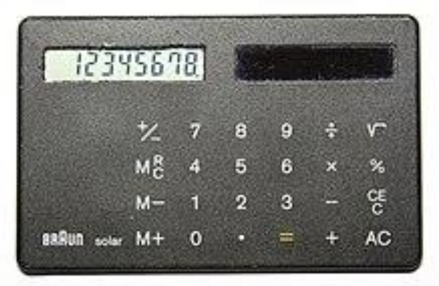
A similar hacker culture in the USA revolved around the HP-41, which was also noted for a large number of undocumented features and was much more powerful than B3-34.

Technical improvements

A calculator which runs on solar and battery power

Through the 1970s the hand-held electronic calculator underwent rapid development. The red LED and blue/green vacuum fluorescent displays consumed a lot of power and the calculators either had a short battery life (often measured in hours, so rechargeable nickel-cadmium batteries were common) or were large so that they could take larger, higher capacity batteries. In the early 1970s liquid-crystal displays (LCDs) were in their infancy and there was a great deal of concern that they only had a short operating lifetime. Busicom introduced the Busicom LE-120A "HANDY" calculator, the first pocket-sized calculator and the first with an LED display, and announced the Busicom LC with LCD. However, there were problems with this display and the calculator never went on sale. The first successful calculators with LCDs were manufactured by Rockwell International and sold from 1972 by other companies under such names as: Dataking LC-800, Harden DT/12, Ibico 086, Lloyds 40, Lloyds 100, Prismatic 500 (a.k.a. P500), Rapid Data Rapidman 1208LC. The LCDs were an early form using the Dynamic Scattering Mode DSM with the numbers appearing as bright against a dark background. To present a high-contrast display these models illuminated the LCD using a filament lamp and solid plastic light guide, which negated the low power consumption of the display. These models appear to have been sold only for a year or two.

A more successful series of calculators using a reflective DSM-LCD was launched in 1972 by Sharp Inc with the Sharp EL-805, which was a slim pocket calculator. This, and another few similar models, used Sharp's Calculator On Substrate (COS) technology. An extension of one glass plate needed for the liquid crystal display was used as a substrate to mount the needed chips based on a new hybrid technology. The COS technology may have been too costly since it was only used in a few models before Sharp reverted to conventional circuit boards.



Credit-card-sized, solar-powered calculator by Braun (1987)

In the mid-1970s the first calculators appeared with field-effect, twisted nematic (TN) LCDs with dark numerals against a grey background, though the early ones often had a yellow filter over them to cut out damaging ultraviolet rays. The advantage of LCDs is that they are passive light modulators reflecting light, which require much less power than light-emitting displays such as LEDs or VFDs. This led the way to the first credit-card-sized calculators, such as the Casio Mini Card LC-78 of 1978, which could run for months of normal use on button cells.

There were also improvements to the electronics inside the calculators. All of the logic functions of a calculator had been squeezed into the first "calculator on a chip" integrated circuits (ICs) in 1971, but this was leading edge technology of the time and yields were low and costs were high. Many calculators continued to use two or more ICs, especially the scientific and the programmable ones, into the late 1970s.

The power consumption of the integrated circuits was also reduced, especially with the introduction of CMOS technology. Appearing in the Sharp "EL-801" in 1972, the transistors in the logic cells of CMOS ICs only used any appreciable power when they changed state. The LED and VFD displays often required added driver transistors or ICs, whereas the LCDs were more amenable to being driven directly by the calculator IC itself.

With this low power consumption came the possibility of using solar cells as the power source, realised around 1978 by calculators such as the Royal Solar 1, Sharp EL-8026, and Teal Photon.

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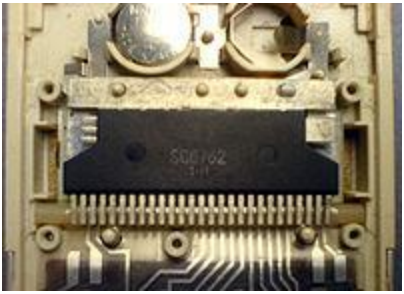
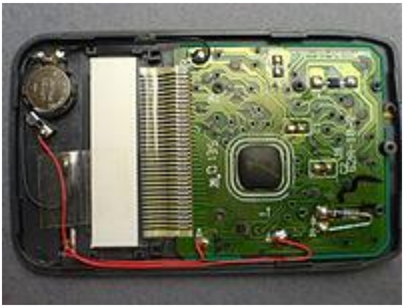
The interior of a Casio fx-20 scientific calculator from the mid-1970s, using a VFD. The processor integrated circuit (IC) is made by NEC. Discrete electronic components like capacitors and resistors and the IC are mounted on a printed circuit board (PCB). This calculator uses a battery pack as a power source.



The processor chip (integrated circuit package) inside a 1981 Sharp pocket calculator, marked SC6762 1•H. An LCD is directly under the chip. This was a PCB-less design. No discrete components are used. The battery compartment at the top can hold two button cells.

Inside a Casio scientific calculator from the mid-1990s, showing the processor chip (small square, top-middle, left), keypad contacts, right (with matching contacts on the left), the back of the LCD (top, marked 4L102E), battery compartment, and other components. The solar cell assembly is under the chip.

- 

The interior of a newer (ca. 2000) pocket calculator. It uses a button battery in combination with a solar cell. The processor is a "Chip on Board" type, covered with dark epoxy.

Mass market phase

At the start of the 1970s, hand-held electronic calculators were very costly, at two or three weeks' wages, and so were a luxury item. The high price was due to their construction requiring many mechanical and electronic components which were costly to produce, and production runs that were too small to exploit economies of scale. Many firms saw that there were good profits to be made in the calculator business with the margin on such high prices. However, the cost of calculators fell as components and their production methods improved, and the effect of economies of scale was felt.

By 1976, the cost of the cheapest four-function pocket calculator had dropped to a few dollars, about 1/20th of the cost five years before. The results of this were that the pocket calculator was affordable, and that it was now difficult for the manufacturers to make a profit from calculators, leading to many firms dropping out of the business or closing down. The firms that survived making calculators tended to be those with high outputs of higher quality calculators, or producing high-specification scientific and programmable calculators.

Mid-1980s to present

The Elektronika MK-52 was a programmable RPN-style calculator that accepted extension modules; it was manufactured in the Soviet Union from 1985 to 1992

The first calculator capable of symbolic computing was the HP-28C, released in 1987. It could, for example, solve quadratic equations symbolically. The first graphing calculator was the Casio fx-7000G released in 1985.

The two leading manufacturers, HP and TI, released increasingly feature-laden calculators during the 1980s and 1990s. At the turn of the millennium, the line between a graphing calculator and a handheld computer was not always clear, as some very advanced calculators such as the TI-89, the Voyage 200 and HP-49G could differentiate and integrate functions, solve differential equations, run word processing and PIM software, and connect by wire or IR to other calculators/computers.

The HP 12c financial calculator is still produced. It was introduced in 1981 and is still being made with few changes. The HP 12c featured the reverse Polish notation mode of data entry. In 2003 several new models were released, including an improved version of the HP 12c, the "HP 12c platinum edition" which added more memory, more built-in functions, and the addition of the algebraic mode of data entry.

Calculated Industries competed with the HP 12c in the mortgage and real estate markets by differentiating the key labeling; changing the “I”, “PV”, “FV” to easier labeling terms such as "Int", "Term", "Pmt", and not using the reverse Polish notation. However, CI's more successful calculators involved a line of construction calculators, which evolved and expanded in the 1990s to present. According to Mark Bollman, a mathematics and calculator historian and associate professor of mathematics at Albion College, the "Construction Master is the first in a long and profitable line of CI construction calculators" which carried them through the 1980s, 1990s, and to the present.

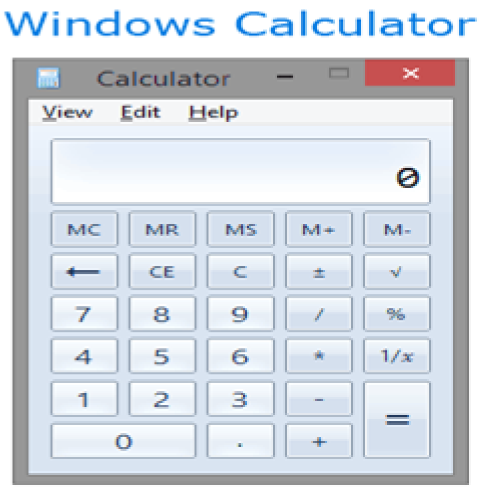
Personal computers often come with a calculator utility program that emulates the appearance and functions of a calculator, using the graphical user interface to portray a calculator. One such example is Windows Calculator. Most personal data assistants (PDAs) and smartphones also have such a feature.

USE ICT IN EDUCATION

In most countries, students use calculators for schoolwork. There was some initial resistance to the idea out of fear that basic or elementary arithmetic skills would suffer. There remains disagreement about the importance of the ability to perform calculations in the head, with some curricula restricting calculator use until a certain level of proficiency has been obtained, while others concentrate more on teaching estimation methods and problem-solving. Research suggests that inadequate guidance in the use of calculating tools can restrict the kind of mathematical thinking that students engage in. Others have argued that calculator use can even cause core mathematical skills to atrophy, or that such use can prevent understanding of advanced algebraic concepts. In December 2011 the UK's Minister of State for Schools, Nick Gibb, voiced concern that children can become "too dependent" on the use of calculators. As a result, the use of calculators is to be included as part of a review of the Curriculum. In the United States, many math educators and boards of education have enthusiastically endorsed the National Council of Teachers of Mathematics (NCTM) standards and actively promoted the use of classroom calculators from kindergarten through high school.

A calculator may refer to any of the following:

1. **Calc** is the name of the spreadsheet program used in OpenOffice.



2. An electronic hardware device or software capable of performing mathematical calculations such as addition, multiplication, subtraction, or division. The Casio Computer Company developed the first electronic calculator in 1957.

Since then, calculators have come in many sizes, and they are also built into most operating systems on computers, as well as smartphones and tablets.

The picture is an example of the **Calculator** software program included in every version of Microsoft Windows.

Running the calculator

Users running Microsoft Windows can access the Windows calculator by following the steps below.

Windows 10 users

1. Click the **Start** button.
2. Click the **All apps** option.
3. Click the **Calculator** utility.

OR

1. Press the shortcut keys **Windows key + X**.
2. In the Power User Task Menu, click the **Run** option.
3. Type **calc** and press Enter.

Windows 8 users

1. From the Windows Start screen, type **calc**.

Windows 95 to Windows 7 users

1. Click the **Start** button.
2. In the Start menu, click **All Programs** or **Programs**.

3. In the programs list, click the **Accessories** folder.

4. Select the **Calculator** utility.

OR

1. Click the **Start** button.

2. In the Start menu, click the Run option.

3. Type **calc** and press Enter.

Windows Calculator tips

Tip

By default, the Windows Calculator is set to Standard mode. The mode can be changed by clicking **View** in the top menu, then choosing **Scientific**. Scientific mode gives the user more options and abilities.

Note

In Windows 10, Calculator does not have a top menu. Instead, click on the button with three horizontal lines stacked vertically, near the top left of the window, and select **Scientific**.

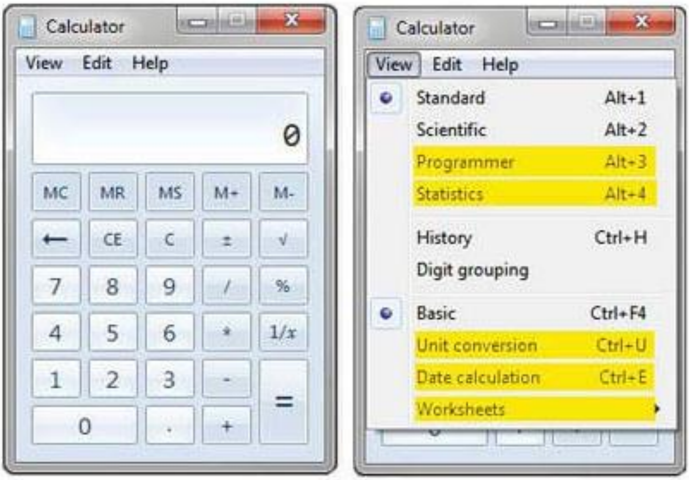
Tip

By default, digit grouping in the Windows Calculator is disabled. Enabling this feature causes your long numbers to have commas. For example, instead of 10000000, it would display as 10,000,000. To enable this feature, click **View** in the top menu and select the **Digit grouping** option.

Note

In Windows 10, the Calculator uses digit grouping by default.

For Windows 7 and above users, Microsoft has included a much more sophisticated calculator. As can be seen in the picture, several new features that have been highlighted and are not available in previous versions of Windows. Additional information and tips on this calculator is on our Windows 7 Calculator tips page.



Basic view New features highlighted

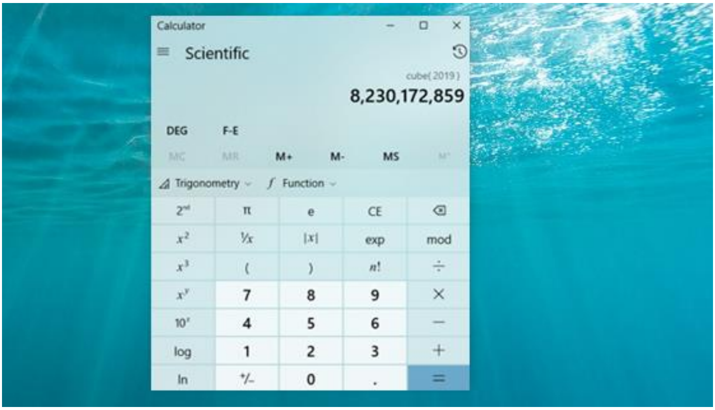
Linux users

Users running Linux and Unix can run the bc command or dc command to open the calculator from the command line.

- The Calculator app for Windows 10 is a touch-friendly version of the desktop calculator in previous versions of Windows.

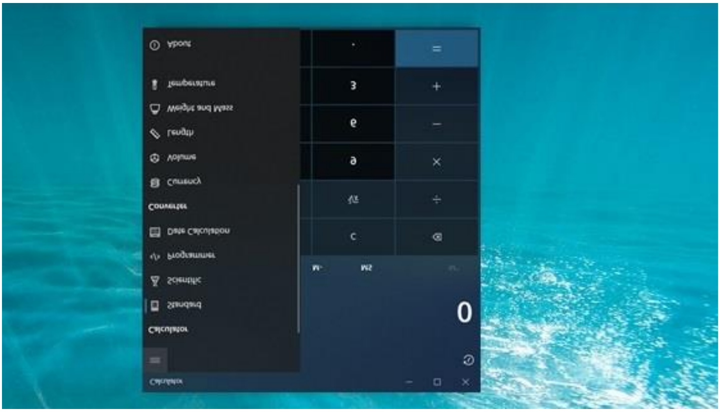
• You can open multiple calculators at the same time in resizable windows on the desktop and switch between Standard, Scientific, Programmer, Date calculation, and Converter modes.

• To get started, select the **Start** button, and then select **Calculator** in the list of apps.



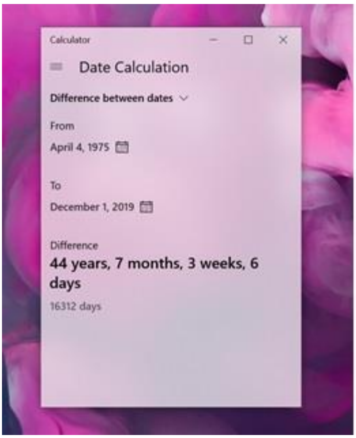
Switch modes

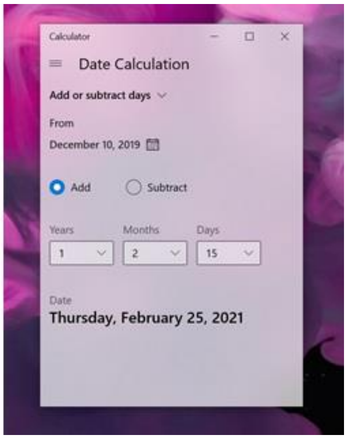
• Use **Standard** mode for basic math, **Scientific** for advanced calculations, **Programmer** for binary code, **Date calculation** for working with dates, and **Converter** for converting units of measurement. Select the **Open Navigation** button to switch modes.



Date calculations

• Switch to **Date Calculation** to calculate the diffrence between two dates or add or subtract days to a date.



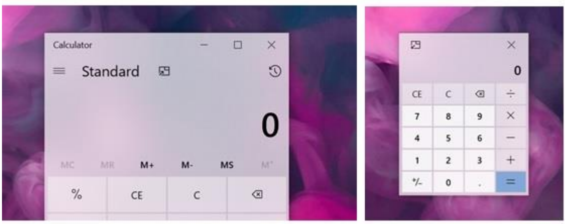


Currency converter

• Switch to **Currency** converter to convert between more than 100 different currencies from around the world. Conversion works offline too, making this mode even more useful if you are roaming internationally and do not have a data connection.

Keep on top

• Select the **Keep on Top** button in **Standard** mode to keep the Calculator windows on top of other windows as you work.



QUESTIONS

1.When was created calculator?

2. Which company did develop calculator?

3. What devices support this software calculator?

DIGITAL LIBRARIES: FUNCTIONALITY, USABILITY, AND ACCESSIBILITY

Libraries are redesigning services and information products to add value to their services and to satisfy the changing information needs of the user community. Traditional libraries are still handling largely printed materials that are expensive and bulky. Information seekers are no longer satisfied with only printed materials. They want to supplement the printed information with more dynamic electronic resources. Demands for digital information are increasing. Digital libraries will start gaining ground in India in the present century. We are heading toward an environment in which digital information may substitute for much print-based information. A library's existence does not depend on the physical form of documents. Its mission is to link the past and the present, and help shape the future by preserving the records of human culture, as well as integrating emerging information technologies. This mission is unlikely to change in the near future. Digital libraries come in many forms. They attempt to provide instant access to digitized information and consist of a variety of information, including multimedia. Definition A digital library is a library in which collections are stored in digital formats (as opposed to print, microform, or other media) and accessible by computers.

The content may be stored locally, or accessed remotely. The first published use of the term may have been in a 1988 report to the Corporation for National Research Initiatives. The term was first popularized by the NSF/DARPA/NASA Digital Libraries Initiative in 1994. Bush (1945) created a vision based on experience ("Digital library.") The Digital Library Federation defines digital libraries as: Organizations that provide the resources, including the specialized staff, to select, structure, offer intellectual access to, interpret, distribute, preserve the integrity of, and ensure the persistence over time of collections of digital works so that they are readily available for use by a defined community or set of communities. (Shiri 2003) The DELOS Digital Library Reference Model defines a digital library as: An organization, which might be virtual, that comprehensively collects, manages and preserves for the long term rich digital content, and offers to its user communities specialized functionality on that content, of measurable quality and according to codified policies. ("Digital Library") "Digital Libraries: Functionality, Usability, and Accessibility," Dr Mayank Trivedi. Library Philosophy and Practice 2010 (May) 2 A digital library is not a single entity. It requires technology link the resources of many collections. The links between digital libraries and their resources are transparent to users. Digital library collections are not limited to document surrogates (bibliographic records. They are the actual digital objects such as images, texts, etc. Lynch (1994) says that, “digital Libraries ... [provide] users with coherent sccess to a very large, organized repository of information and knowledge.” According to Berkeley Digital Library Project, University of California, the digital library will be a collection of distributed information sources. The contrast between traditional and digital libraries is presented below Traditional Libraries Digital or Electronic Library Print collection All resources in digital form. Stable, with slow evolution Dynamic and ephemeral Individual objects not directly linked with each other. Multi-media and fractal objects Flat structure with minimal contextual metadata Scaffolding of data structures and richer contextual metadata. Scholarly content with validation process More than scholarly content with various validation processes Limited access points and centralized management Unlimited access points, distributed collections and access control The physical and logical organization correlated.

The physical and logical organization may be virtually One way interactions Dynamic realtime dialogue Free and universal access. Free as well as fee based. Characteristics of Digital Libraries Recent developments in library technology and practices have helped bring some of Lancaster 's paperless society to reality. The effects that digital technology has brought include: (Jebaraj and Deivasigimani 2003) Digital library collections contain permanent documents. The digital environment will enable quick handling and/or ephemeral information. Digital libraries are based on digital technologies. The assumption that digital libraries will contain only digital materials may be wrong. Digital libraries are often used by individuals working alone. The physical boundaries of data have been eliminated. Support for communications and collaboration is as important as information-seeking. Compression of data storage is enabling publication and storage of digital information. Telecommunications is facilitating the storage, retrieval, use, and exchange of digital resources. Function of Digital Library Access to large amounts of information to users wherever they are and whenever they need it. Access to primary information sources. Support multimedia content along with text Network accessibility on Intranet and Internet User-friendly interface Hypertext links for navigation Client-server architecture “Digital Libraries: Functionality, Usability, and Accessibility,” Dr Mayank Trivedi. Library Philosophy and Practice 2010 (May) 3 Advanced search and retrieval. Integration with other digital libraries. Purpose of

Digital Library Expedite the systematic development of procedures to collect, store, and organize, information in digital form. Promote efficient delivery of information economically to all users. Encourage co-operative efforts in research resource, computing, and communication networks. Strengthen communication and collaboration between and among educational institutions. Take leadership role in the generation and dissemination of knowledge Components The components of a digital library are: Infrastructure Digital Collection Systems function Telecommunication facility Human resources Planning for Digital Library A digital library committee should be formed to plan for its creation and maintenance. The members must be from various library departments, and, if necessary, consultants can be hired.

There are at least two ways of developing a digital library: converting a traditional library into a digital library, and direct development of a digital library. Planning includes: IT Infrastructure Digitization Access Staffing Furniture, equipment, and space Services Funding Creation of Digital Resources Database of digital material that is open to all users over the campus-wide LAN. High bandwidth Internet connectivity Focus selectively on acquiring digital resources Electronic journals, and gradual elimination of print subscriptions Licensed databases Creation of local digital content available within the university Advantages of a Digital Library The advantages of digital libraries include "Digital Libraries: Functionality, Usability, and Accessibility," Dr Mayank Trivedi. Library Philosophy and Practice 2010 (May) 4 Nearly unlimited storage space at a much lower cost Re-allocate funds from some staff, collection maintenance, and additional books. No physical boundary Round the clock availability Multiple access Enhanced information retrieval. Preservation for some print material Added value Universal accessibility Limitations Lack of screening or validation Lack of preservation of a fixed copy (for the record and for duplicating scientific research) Lack of preservation of "best in class" Difficulty in knowing and locating everything that is available, and differentiating valuable from useless information. Job loss for traditional publishers and librarians Costs are spread and many become hidden.

Digital Library Initiatives in India India is in the experimental stages of digital libraries. Barring the Health Education Library for People (HELP), Mumbai, the Tata Institute of Fundamental Research (TIFR), Mumbai, IIT Kharagpur, and National Centre for Science Information (NCSI), Bangalore, a majority of libraries provide bibliographic access only. IASLIC-LIST and the LIS-FORUM, along with the electronic newsletter, INFOWATCH provide professional information. Information today and Tomorrow , INFLIBNET Newsletter , and the DESIDOC

Bulletin of Information Technology (D-BIT) are a few other sources of current information on the use of ICTs and networks. Research and development activities regarding digital libraries are being undertaken in some institutions, for example, at the Education and Research network (ERNET) of Department of Electronics, Gol (http://www.doe.ernet.in) and the electronic library being developed at the Indian National Scientific Documentation Centre (NISCAIR), New Delhi (http://www.NISCAIR.org). A brief account of some of the resources and services is presented below. Searchable databases on the web from Central Library of Indian Institute of Technology, Kharagur (IIT-Kgp) (http://144.16.192.18 or http://libweb.iitkgp.ernet.in) Digitization at IIT-Kgp Library initiated at the beginning of 1990s. IIT-Kgp is one of the six premier institutions of quality education in engineering and technology, the Indian Institute of Technology (IITs). Electronic current awareness bulleting „Infowatch' beginning in July 1996 by the University Grants Commission (UGC). (http://144.16.72.150/ncsi/iw.html) LIS-FORUM, a discussion forum sponsored by NCSI, Bangalore. (http://144.16.72.150/ncsi/services/lis-archive.html) Development of OPACs in many libraries such as Centre on Rural Documentation CORD of National Institute of Rural Development (NIRD), Hyderabad (http://www.nird.org/clic/index.html and http://www.nird.org/clic/L.html) Index of Hitesranjan Sanyal Memorial Collection (HSMC) at the Centre for Studies in Social Sciences (CSSS), Calcutta. (http://www.iisg.nl/asia/cssc.htm and http://www.socialsciencecal.org) Health Education Library for People (HELP), in Mumbai. HELP is a privately managed site providing health related information and managing an online catalogue of over 15,000 documents (http://www.healthlibrary.com) "Digital Libraries: Functionality, Usability, and Accessibility," Dr Mayank Trivedi. Library Philosophy and Practice 2010 (May) 5 The situation in India regarding digital libraries is very peculiar. Many government agencies, as well as institutions, mostly in the public sector, are engaged in some sort of work regarding the digitization of libraries. Examples clearly indicate that the potential of ICTs for developing digital libraries has not been fully realized by the GoI. While one government agency is providing support for one particular aspect, the other is focusing elsewhere, without any coordinated effort by a nodal agency. Conclusion There will be continuing expansion of digital library activities. LIS and computer science professionals face challenges that will lead to improved systems. More and more libraries will have departments and programs in the digital library arena. Digital libraries will build upon work being done in the information and data management area. Digital libraries provide an effective means to distribute learning resources to students and other users. Planning a digital library requires thoughtful analysis of the organization and its users, and an acknowledgement of the cost and the need for infrastructure and ongoing maintenance (Adams, Jansen, and Smith 1999). Digital Libraries present opportunities and challenges for the library and information communities and all stakeholders.

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EDUCATIONAL HARDWARE AND SOFTWARE: DIGITAL TECHNOLOGY AND DIGITAL EDUCATIONAL CONTENT

Nowadays the emphasis is on new class model termed as New Generation Classrooms. Such classrooms have its arrangement and equipment to support the constructivist approach in the educational process and the main emphasis is also on pupils' access to modern digital technologies. Another important part of the modern educational process is the content of education and software tools to support building new knowledge. We point out some useful software tools to support inquiry-based approaches to acquiring new knowledge pupils themselves and also on the possibility of digital educational content creation by teacher.

Teacher creates digital learning objects either himself or uses already prepared objects from different repositories. The New Generation Classrooms combine various traditional teaching methods with the most modern technologies and digital teaching tools which can make the educational process more engaging and the building of pupils' new knowledge more effectively. In the article there are the results of the first part of the research realized in China within the student grant project “ICT in Mathematics at elementary schools in Olomouc and Leshan City”. Within this project explores the availability and use of ICT in math teaching at primary schools in the Czech Republic and China including competencies and attitudes of teachers towards ICT.

Successful of realization modern teaching methods nowadays mean especially effective use of modern digital technologies and effective use of digital learning materials. Digital technology is supporting the education process for some time but nowadays the emphasis is on new class model termed as New Generation Classrooms. Such classrooms its arrangement and equipment provide a stimulating environment for pupils which raises pupils' motivation to independent work and supports the constructivist approach in the educational process such as inquiry-based education. The main emphasis at these termed classrooms is also pupils' access to modern digital technologies which also function as a motivation but mainly give pupils the newest opportunities to their own creative activities. Using these technologies they acquire almost unlimited source of information, tools for their independent inquiry and experimentation or various forms of online collaboration and knowledge sharing. On independent pupils' inquiry and experimentation today points out constructivist approach called inquiry-based education, which also emphasizes active use of ICT in the classroom and also during self-study and in preparation for lessons. Inquiry-based education means such instruction which includes activities focused on the exploration and discovery, teaching inspired by inquiry and research methods, which very well supports and enhances the potential of digital technology. Another important part of the modern educational process is the content of education and software tools to support building new knowledge. Digital educational content are interactive reusable digital learning objects whose potential would not be only access via Internet anytime and anywhere, but especially explanatory help for pupils to understand phenomena, whose introduction in the traditional way of teaching mathematics could be problematic.

Teacher creates digital learning objects either himself or uses already prepared objects either unchanged or is able to modify the acquired objects and align with required educational goals and the actual content of teaching discipline. So he is able to modify it in the specialized software for creating interactive digital learning objects which is e.g. programs for creating animation and software for creating digital learning objects designed for the interactive boards. These practices, technology and digital learning objects can be applied to the educational process from primary education to university education. For this purpose it is necessary to have a suitably prepared digital learning objects including access to these objects, i.e. it's necessary to have during own education access to information and communication technologies.

The research is also focused on competencies of teachers in ICT and their attitudes towards ICT. Comparison of using ICT in schools in these regions will be performed and especially optimal ways of using ICT in mathematics at elementary schools will be searched for. The first part of the research has already been carried out in China. Through a questionnaire survey and interviews with teachers were investigated following topics: ICT implementation to schools; use of digital technologies, software and electronic resources in lessons; ICT competencies of teachers; teachers' attitudes towards the implementation and use of ICT in the educational process.

ICT AND NEW GENERATION CLASSROOMS

New generation classrooms represent a model which could be in primary mathematics education rewarding both for motivation in the classroom and also for self-constructing new knowledge of pupils. It has been proven many times that challenging and stimulating environment has a direct impact on pupils' learning motivation. In these classrooms occur connection of modern didactic tools with principles of pedagogical constructivism which emphasizes the pupil's own experience which is generally perceived as not transferable. Therefore we must give pupils the chance and space to develop creative thinking and build their own knowledge. Space is here an adequate classroom environment providing access to modern didactic resources and space for their own inquiry. Here, pupils have a chance to explore, inquiry, and experiment which results in achieving the desired goal newly acquired knowledge and also feeling of success and joy. In accordance with these principles can be expected that new generation classrooms are suitable space and instrument for the math teaching too.

Teacher's role is especially to start the pupils' learning process, manage this process and direct pupils to build their own new knowledge. New generation classrooms only provide space and resources to the process of cognition. Unlike commonly equipped classrooms should be emphasized such spatial arrangement to facilitate the movement of pupils in the classroom because of various cooperation, pupils' project activities, access to various utilities and especially to digital technologies. Digital technologies (computers, tablets, interactive whiteboards, visualizers, different projections, internet and software tools) are an integral part of new generation classrooms. These modern didactic resources have not only a motivational character. With proper use the curriculum becomes more engaging, more illustrative, information more accessible and when is properly chosen software tool, process inquiry and creation of new knowledge can be more efficiently. Fundamentally changes also educational content.

New generation classrooms are able to accelerate and enhance access to quality information which is available anytime, anywhere and on any device, as well as access to online resources. Lesson thus becomes personalized and develops not only professional knowledge of the subject, but also focuses on skills development that pupils must master, to be successful in further education. If we focus on the motivational aspect of the new generation classrooms in mathematics using new digital technologies, so the actual trend is evidently teaching with tablets. It already has in the Czech Republic several years of experience.

DIGITAL LEARNING OBJECTS

New generation classrooms and neither alone digital technology are not possible to imagine in education without educational content. These contents are different forms of digital learning objects (DLO), respectively specific software for their creating and distribution. New Media Consortium (NMC) defines digital learning objects as a group of materials (texts, hypertexts, graphics, pictures, simulations, films, sounds, etc.) which is reasonably structured and is based on educational aims and objectives. It is multimedia content, educational content, educational software or software instruments used in computer supported education . DLO can be understood as a category of multimedia learning aids. Dostál defines multimedia learning aid as “a digital tool integrating various forms of documents and data (e.g. texts, tables, animations, pictures, sounds, video, etc.), which present and copy he reality to help and simplify the education.” A significant characteristic of DLO is their unrestricted accessibility anytime and their repeatable applicability. Digital character of the entities enables to spread them easily via Internet or Intranet, which means they are accessible to any user (depending on technological conditions) at the same time.

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EDUCATIONAL SOFTWARE

Educational software is a term used for any computer software which is made for an educational purpose. It encompasses different ranges from language learning software to classroom management software to reference software, etc. The purpose of all this software is to make some part of education more effective and efficient.

Categories of Educational Software

Courseware

Courseware is a term that combines the words 'course' with 'software'. It was originally used to describe additional educational material intended as kits for teachers or trainers or as tutorials for students, usually packaged for use with a computer. The term's meaning and usage has expanded and can refer to the entire course and any additional material when used in reference an online or 'computer formatted' classroom. Many companies are using the term to describe the entire "package" consisting of one 'class' or 'course' bundled together with the various lessons, tests, and other material needed. The courseware itself can be in different formats: some are only available online, such as Web pages, while others can be downloaded as PDF files or other types of document. Many forms of educational technology are now covered by the term courseware. Most leading educational companies solicit or include courseware with their training packages.

Classroom aids

Some educational software is designed for use in school classrooms. Typically such software may be projected onto a large whiteboard at the front of the class and/or run simultaneously on a network of desktop computers in a classroom. The most notable are SMART Boards that use SMART Notebook to interact with the board which allows the use of pens to digitally draw on the board. This type of software is often called classroom management software. While teachers often choose to use educational software from other categories in their IT suites (e.g. reference works, children's software), a whole category of educational software has grown up specifically intended to assist classroom teaching. Branding has been less strong in this category than in those oriented towards home users. Software titles are often very specialized and produced by various manufacturers, including many established educational book publishers.

Assessment software

Moodle is a very popular assessment websites used by teachers to send assignments and grade students' works.

With the impact of environmental damage and the need for institutions to become "paperless",more educational institutions are seeking alternative ways of assessment and testing, which has always traditionally been known to use up vasts amount of paper. Assessment software refers to software with a primary purpose of assessing and testing students in a virtual environment.

Assessment software allows students to complete tests and examinations using a computer, usually networked. The software then scores each test transcript and outputs results for each student. Assessment software is available in various delivery methods, the most popular being self-hosted software, online software and hand-held voting systems. Proprietary software and open-source software systems are available. While technically falling into the Courseware category (see above), Skill evaluation lab is an example for Computer-based assessment software with PPA-2 (Plan, Prove, Assess) methodology to create and conduct computer based online examination. Moodle is an example of open-source software with an assessment component that is gaining popularity. Other popular international assessment systems include Assessment Master, Google Classroom, Blackboard Learn, EvaluNet XT and Eduroan.

Reference software

Many publishers of print dictionaries and encyclopedias have been involved in the production of educational reference software since the mid-1990s. They were joined in the reference software market by both startup companies and established software publishers, most notably Microsoft.

The first commercial reference software products were reformulations of existing content into CD-ROM editions, often supplemented with new multimedia content, including compressed video and sound. More recent products made use of internet technologies, to supplement CD-ROM products, then, more recently, to replace them entirely.

Wikipedia and its offspins (such as Wiktionary) marked a new departure in educational reference software. Previously, encyclopedias and dictionaries had compiled their contents on the basis of invited and closed teams of specialists. The Wiki concept has allowed for the development of collaborative reference works through open cooperation incorporating experts and non-experts.

Custom platforms

Some manufacturers regarded normal personal computers as an inappropriate platform for learning software for younger children and produced custom child-friendly pieces of hardware instead. The hardware and software is generally combined into a single product, such as a child laptop-lookalike. The laptop keyboard for younger children follows an alphabetic order and the qwerty order for the older ones. The most well-known example are Leapfrog products. These include imaginatively designed hand-held consoles with a variety of pluggable educational game cartridges and book-like electronic devices into which a variety of electronic books can be loaded. These products are more portable than laptop computers, but have a much more limited range of purposes, concentrating on literacy.

While mainstream operating systems are designed for general usages, and are more or less customized for education only by the application sets added to them, a variety of software manufacturers, especially Linux distributions, have sought to provide integrated platforms for specifically education.

Corporate training and tertiary education

Earlier educational software for the important corporate and tertiary education markets was designed to run on a single desktop computer (or an equivalent user device). In the years immediately following 2000, planners decided to switch to server-based applications with a high degree of standardization. This means that educational software runs primarily on servers which may be hundreds or thousands of miles from the actual user. The user only receives tiny pieces of a learning module or test, fed over the internet one by one. The server software decides on what learning material to distribute, collects results and displays progress to teaching staff. Another way of expressing this change is to say that educational software morphed into an online educational service. US Governmental endorsements and approval systems ensured the rapid switch to the new way of managing and distributing learning material.

Specific educational purposes

There are highly specific niche markets for educational software, including:

- teacher tools and classroom management software

(remote control and monitoring software, filetransfer software, document camera and presenter, free tools,...)

- Driving test software
- Interactive geometry software
- Language learning software
- Mind Mapping Software which provides a focal point for discussion, helps make classes more interactive, and assists students with studying, essays and projects.
- Designing and printing of card models for use in education - eg. Designer Castles for BBC Micro and Acorn Archimedes platforms
- Notetaking (Comparison of notetaking software)
- Software for enabling simulated dissection of human and animal bodies (used in medical and veterinary college courses)
- Spelling tutor software
- Typing tutors
- Reading Instruction
- Medical and healthcare educational software

Video Game and Gamification

Video games can be used to teach a user technology literacy or more about a subject. Some operating systems and mobile phones have these features. A notable example is Microsoft Solitaire, which was developed to familiarize users with the use of graphical user interfaces, especially the mouse and the drag-and-drop technique.

Mavis Beacon Teaches Typing is a largely know program with built in mini-games to keep the user entertained while improving their typing skills.

Gamification is the use of game design elements in nongame contexts and has been shown to be effective in motivating behavior change.

By seeing game elements as "motivational affordances," and formalizing the relationship between these elements and motivational affordances.

Classcraft is a software tool used by teachers that has games elements alongside an educational goal. Tovertafel is a games console designed for remedial education and counter-acting the effects of dementia.

Effects and Use of Educational Software

Tutor Based Software

Tutor based education software is defined as software that mimics the teacher student one on one dynamic of tutoring with software in place of a teacher.

Research was conducted to see if this type of software would be effective in improving students understanding of material. It concluded that there was a positive impact which decreased the amount of time students need to study for and relative gain of understanding.

Helping Those With Disabilities

A study was conducted to see the effects of education software on children with mild disabilities.

The results were that the software was a positive impact assisting teaching these children social skills though team based learning and discussion, videos and games.

Education Software Evaluation

There is a large market of educational software in use today. A team decided that they were to develop a system in which educational software should be evaluated as there is no current standard.

It is called the Construction of the Comprehensive Evaluation of Electronic Learning Tools and Educational Software (CEELTES).

The software to be evaluated is graded on a point scale in four categories: the area of technical, technological and user attributes; area of criteria evaluating the information, content and operation of the software; the area of criteria evaluating the information in terms of educational use, learning and recognition; the area of criteria evaluating the psychological and pedagogical use of the software.

Use In Higher Education

In university level computer science course, learning logic is an essential part of the curriculum.

There is a proposal on using two logistical education tool FOLST and LogicChess to understand First Order Logic for university students to better understand the course material and the essentials of logistical design.

Trends In Educational Software

VR/AR are increasingly being used in the classroom as their technology becomes more powerful and affordable. ClassVR is a company that makes their own headsets and software specifically for using VR in the classroom.

They have a vast amount of lesson plans that go along with their product. VR/AR are used as reinforcement of old concepts and as a way to introduce new ones as well.

Many believe that there is great potential to make VR/AR common place to improve learning.

Artificial Intelligence (AI)

AI has become increasingly more advanced over the years. Now it is being used in the classroom as teaching assistants that students can ask questions to and it will find and explain the answer. They're being used because it reduces the amount of time a teacher needs to spend on a specific question allow the teacher to explain the more complex material.

One of the most popular examples is Brainly, a website that is used for asking educational questions.

Once a student asks a question, another student can answer it and Brainly will check its databases to make sure that the information is correct.

ICT IN EDUCATION/THE USES OF ICTS IN EDUCATION

Education policymakers and planners must first of all be clear about what educational outcomes (which is discussed above) are being targeted.These broad goals should guide the choice of technologies to be used and their modalities of use.

The potential of each technology varies according to how it is used. Haddad and Draxler identify at least five levels of technology use in education: presentation, demonstration, drill and practice, interaction, and collaboration.

Each of the different ICTs—print, audio/video cassettes, radio and TV broadcasts, computers or the Internet—may be used for presentation and demonstration, the most basic of the five levels. Except for video technologies, drill and practice may likewise be performed using the whole range of technologies. On the other hand, networked computers and the Internet are the ICTs that enable interactive and collaborative learning best; their full potential as educational tools will remain unrealized if they are used merely for presentation or demonstration. ICTs stand for information and communication technologies and are defined, for the purposes of this primer, as a “diverse set of technological tools and resources used to communicate, and to create, disseminate, store, and manage information.” These technologies include computers, the Internet, broadcasting technologies (radio and television), and telephony. to be used and their modalities of use.

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QUESTIONS

1. How have radio and TV broadcasting been used in education?

2. What is teleconferencing and what have been its educational uses?

3. How have computers and the Internet been used for teaching and learning?

4. What does it mean to learn about computers and the Internet?

5. What about learning with computers and the Internet?

6. What does learning through computers and the Internet mean?

7. How are computers and the Internet used in distance education?

8. What is telecollaboration?

9. How have radio and TV broadcasting been used in education?

Radio and television have been used widely as educational tools since the 1920s and the 1950s, respectively. There are three general approaches to the use of radio and TV broadcasting in education:

- direct class teaching, where broadcast programming substitutes for teachers on a temporary basis;
- school broadcasting, where broadcast programming provides complementary teaching and learning resources not otherwise available; and
- general educational programming over community, national and international stations which provide general and informal educational opportunities.

The notable and best documented example of the direct class teaching approach is Interactive Radio Instruction (IRI).This consists of “ready-made 20-30 minute direct teaching and learning exercises to the classroom on a daily basis. The radio lessons, developed around specific learning objectives at particular levels of mathematics, science, health and languages in national curricula, are intended to improve the quality of classroom teaching and to act as a regular, structured aid to poorly trained classroom teachers in under-resourced schools." IRI projects have been implemented in Latin America and Africa. In Asia, IRI was first implemented in Thailand in 1980; Indonesia, Pakistan, Bangladesh and Nepal rolled out their own IRI projects in the 1990s. What differentiates IRI from most other distance education programs is that its primary objective is to raise the quality of learning—and not merely to expand educational access—and it has had much success in both formal and non-formal settings. Extensive research around the world has shown that many IRI projects have had a positive impact on learning outcomes and on educational equity. And with its economies of scale, it has proven to be a cost-effective strategy relative to other interventions.

Mexico's Telesecundaria is another notable example of direct class teaching, this time using broadcast television. The programme was launched in Mexico in 1968 as a cost-effective strategy for expanding lower secondary schooling in small and remote communities. Perraton describes the programme thus:

Centrally produced television programs are beamed via satellite throughout the country on a scheduled basis (8 am to 2 pm and 2 pm to 8 pm) to Telesecundaria schools, covering the same secondary curriculum as that offered in ordinary schools. Each hour focuses on a different subject area and typically follows the same routine—15 minutes of television, then book-led and teacher-led activities. Students are exposed to a variety of teachers on television but have one home teacher at the school for all disciplines in each grade.

The design of the programme has undergone many changes through the years, shifting from a "talking heads"approach to more interactive and dynamic programming that "link[s] the community to the programme around the teaching method. The strategy meant combining community issues into the programs, offering children an integrated education, involving the community at large in the organization and management of the school and stimulating students to carry out community activities."

Assessments of Telesecundaria have been encouraging: drop out rates are slightly better than those of general secondary schools and significantly better than in technical schools.

In Asia, the 44 radio and TV universities in China (including the China Central Radio and Television University), Universitas Terbuka in Indonesia, and Indira Ghandi National Open University have made extensive use of radio and television, both for direct class teaching and for school broadcasting, to reach more of their respective large populations. For these institutions, broadcasts are often accompanied by printed materials and audio cassettes.

Japan's University of the Air was broadcasting 160 television and 160 radio courses in 2000. Each course consists of 15 45-minute lectures broadcast nationwide once a week for 15 weeks. Courses are aired over University-owned stations from 6 am to 12 noon. Students are also given supplemental print materials, face-to-face instruction, and online tutorials..

Often deployed with print materials, cassettes and CD-ROMS, school broadcasting, like direct class teaching,is geared to national curricula and developed for a range of subject areas. But unlike direct class instruction, school broadcasting is not intended to substitute for the teacher but merely as an enrichment of traditional classroom instruction. School broadcasting is more flexible than IRI since teachers decide how they will integrate the broadcast materials into their classes. Large broadcasting corporations that provide school broadcasts include the British Broadcasting Corporation Education Radio TV in the United Kingdom and the NHK Japanese Broadcasting Station. In developing countries, school broadcasts are often a result of a partnership between the Ministry of Education and the Ministry of Information.

Educational programming consists of a broad range of programme types—news programs, documentary programs, quiz shows, educational cartoons, etc.—that afford non-formal educational opportunities for all types of learners.In a sense,any radio or TV programming with informational and educational value can be considered under this type. Some notable examples that have a global reach are the United States-based television show Sesame Street,the all-information television channels National Geographic and Discovery,and the radio programme Voice of America.The Farm Radio Forum, which began in Canada in the 1940s and which has since served as a model for radio discussion programs worldwide, is another example of non-formal educational programming.

What is teleconferencing and what have been its educational uses

Teleconferencing refers to "interactive electronic communication among people located at two or more different places." There are four types of teleconferencing based on the nature and extent of interactivity and the sophistication of the technology:

1) audioconferencing;

2) audio-graphic conferencing,

3) videoconferencing;

and

4) Web-based conferencing.

Audioconferencing involves the live (real-time) exchange of voice messages over a telephone network. When low-bandwidth text and still images such as graphs, diagrams or pictures can also be exchanged along with voice messages, then this type of conferencing is called audiographic. Non-moving visuals are added using a computer keyboard or by drawing/writing on a graphics tablet or whiteboard.

Videoconferencing allows the exchange not just of voice and graphics but also of moving images.

Videoconferencing technology does not use telephone lines but either a satellite link or television network (broadcast/cable). Web-based conferencing, as the name implies, involves the transmission of text, and graphic, audio and visual media via the Internet; it requires the use of a computer with a browser and communication can be both synchronous and asynchronous.

Teleconferencing is used in both formal and non-formal learning contexts to facilitate teacher-learner and learner-learner discussions, as well as to access experts and other resource persons remotely.

In open and distance learning, teleconferencing is a useful tool for providing direct instruction and learner support, minimizing learner isolation.

For instance, an audiographic teleconferencing network between Tianjin Medical University in China and four outlying Tianjin municipalities was piloted in 1999 as part of a multi-year collaboration between Tianjin Medical University and the University of Ottawa School of Nursing funded by the Canadian International Development Agency.

The audio-graphic teleconferencing network aims to provide continuing education and academic upgrading to nurses in parts of Tianjin municipality where access to nursing education has been extremely limited.

Other higher education institutions using teleconferencing in their online learning programs include the Open University of the United Kingdom, Unitar (Universiti Tun Abdul Ruzak) in Malaysia, Open University of Hong Kong, and Indira Gandhi National Open University.

Figure 4.

Box 2. Promoting Learner-Centered Pedagogy through Computers

Project CHILD (Computers Helping Instruction and Learning Development) is a computer-integrated instruction programme developed in 1988 by the University of Florida for grades K-5 (pre-school and primary school). The programme focuses on three subject areas—reading, writing and mathematics. Each Project CHILD classroom has a learning station with between three to six computers. Butzin describes a typical Project CHILD classroom scenario thus:

- A class period begins with the teacher conducting a whole group lesson—let's say an introduction to fractions. After about 10 minutes of direct instruction, the students fan out to their first assigned learning station. Each station will have an activity related to fractions. Some stations will focus on skill practice, while others will focus on concept development. The station activities encompass kinesthetic (hands-on) learning as well as auditory and visual modalities. The teacher assigns instructional software at each computer station to tie in with the lesson objectives.
- As student groups work at their stations, the teacher circulates to help, probe, assess, and encourage students as they work on their assigned tasks. When a student finishes an activity… [s/he] moves on [to the next station] as needed. At the end of the period, the teacher gathers the class together for reflection and discussion on the day's activities.
- Teachers form cross grade subject-specific clusters (K-2 or 3-5) and work with children over three years, the better to judge what software is appropriate for the subject and to allow students to learn at their own pace. Teachers are also given one year training on integration and are provided with research-based materials for lesson planning and technology integration.

Over a decade's worth of research on Project CHILD students have shown that they have scored consistently higher on standardized tests than their counterparts in traditional classrooms, and that the positive effects of the programme have increased over time. Project CHILD students also exhibited better attitudes toward school and learning, and better discipline as well. Project CHILD has been recognized as an effective programme by the U.S. Department of Education's National Diffusion Network and has received funding for nationwide expansion.

Source: Butzin, S., "Project CHILD: A Decade of Success for Young Children". Available Online http://www.thejournal.com/magazine/vault/A2882.cfm Accessed 22 June 2002.

How have computers and the Internet been used for teaching and learning

There are three general approaches to the instructional use of computers and the Internet, namely:

- Learning about computers and the Internet, in which technological literacy is the end goal;
- Learning with computers and the Internet, in which the technology facilitates learning across the curriculum; and
- Learning through computers and the Internet, integrating technological skills development with curriculum applications.
- use for doing different kind of research

What does it mean to learn about computers and the Internet?

Learning about computers and the Internet focuses on developing technological literacy. It typically includes:

- Fundamentals: basic terms, concepts and operations
- Use of the keyboard and mouse
- Use of productivity tools such as word processing, spreadsheets, data base and graphics programs
- Use of research and collaboration tools such as search engines and email
- Basic skills in using programming and authoring applications such as Logo or HyperStudio
- Developing an awareness of the social impact of technological change.

Figure 5.

Box 3. South Korean Universities Go Virtual

South Korea has one of the most advanced ICT infrastructures in the world—computer penetration is extensive, and broadband Internet access is one of the best globally. The pervasiveness of ICT use in South Korean society has spilled over to the higher educational system.

South Korea currently has 15 single-mode virtual universities that offer only ICT-based courses. Among these are the Korea Cyber University, the Korea Digital University, and the Open Cyber University. These universities specialize in lifelong learning and vocational education—a deliberate strategy to prevent unnecessary competition with more established campus-based universities—and have a combined projected enrolment of 17,200 in 2002. Courses offered cover a wide range of fields, including technology, management, law, languages, social sciences, education, and theology.

Online courses are also offered by over 100 of South Korea's dual-mode universities. Ewha Woman's University, for instance, offers Internet-based courses in language, e-learning, drug prevention, in-service teacher training, and Korean and Women's studies for local and foreign students as well as working adults.

The accelerated adoption of virtual education in South Korea was a result of deliberate planning by government. It began in 1998 with the launch of the Virtual University Trial Project (VUTP). With 65 universities and five companies participating, the VUTP was designed to:

1) create a cost-effective virtual education system without diminishing quality;

2) develop and implement Web-based or other types of distance education courses;

3) identify appropriate policies and standards for running a virtual university; and

4) share experiences during the trial period.

Participating institutions experimented with various technologies: satellite broadcasting, videoconferencing, video-on-demand, intranets, and the Internet. Based on the VUTP experience, detailed criteria for establishing virtual universities in South Korea were added to the Lifelong Education Law.

Two years after the VUTP, however, policymakers and educators in South Korea continue to grapple with issues of quality management, capacity building, cost-savings, open access, and the appropriateness of the instructional model for adult learners.

Source: Jung, In Sung, "Virtual Education at the Tertiary Level: The Experience of Korea". Available Online http://www.TechKnowLogia.org… Accessed 4 July 2002.

What about learning with computers and the Internet?

Learning with the technology means focusing on how the technology can be the means to learning ends across the curriculum. It includes:

- Presentation, demonstration, and the manipulation of data using productivity tools
- Use of curriculum-specific applications types such as educational games, drill and practice, simulations, tutorials, virtual

laboratories, visualizations and graphical representations of abstract concepts, musical composition, and expert systems

- Use of information and resources on CD-ROM or online such as encyclopedia, interactive maps and atlases, electronic journals and other references.

Technological literacy is required for learning with technologies to be possible, implying a two-step process in which students learn about the technologies before they can actually use them to learn. However, there have been attempts to integrate the two approaches.

What does learning through computers and the Internet mean?

Learning through computers and the Internet combines learning about them with learning with them. It involves learning the technological skills "just-in-time" or when the learner needs to learn them as he or she engages in a curriculum-related activity. For example, secondary school students who must present a report on the impact on their community of an increase in the price of oil for an Economics class may start doing research online, using spreadsheet and database programs to help organize and analyze the data they have collected, as well using word processing application to prepare their written report.

How are computers and the Internet used in distance education?

Many higher educational institutions offering distance education courses have started to leverage the Internet to improve their programme's reach and quality. The Virtual University of the Monterrey Institute of Technology in Mexico uses a combination of print, live and recorded broadcasts, and the Internet to deliver courses to students throughout Mexico and in several Latin American countries. Similarly, the African Virtual University, initiated in 1997 with funding support from the World Bank, uses satellite and Internet technologies to provide distance learning opportunities to individuals in various English-speaking and French-speaking countries throughout Africa.

At the University of the Philippines Open University, course materials are still predominantly print-based but online tutorials are becoming a convenient alternative to face-to-face tutorials especially for students unwilling or unable to go to UPOU's various physical learning centres. About 70-90% of UPOU's degree courses offer online tutorials as an option, while in several of its non-degree courses tutorials are conducted only online.

But even in Korea, where infrastructure is among the best in the world, and government has put considerable financial and other resources behind an ambitious ICT-based re-tooling of its educational system, challenges to online education persist.

Internet- and Web-based initiatives have also been developed at the secondary education level. The Virtual High School is a result of efforts of a nationwide consortium of school districts in the United States to promote the development and sharing of Web-based courses. In Canada, Open School offers a wide range of courses and resources to grades K-12 teachers and students that meet the requirements of the British Columbia curriculum. Course delivery is done through a mix of broadcast and video, while some courses are delivered totally online.

The biggest movers in e-learning, however, are not found within academe but in the private sector. John Chambers, CEO of Cisco, famously predicted that e-learning would be the next big killer application, and corporations are moving aggressively to fulfill this prediction. Merrill Lynch estimates that the combined higher education and corporate e-learning markets in the US will grow from $US2.3 billion in 2000 to US$18 billion in 2003, with corporate training accounting for almost two thirds of that growth. Indeed, the number of corporate universities have grown from 400 to 1,800 over the last 13 years. Corporate universities are primarily in-house organizations in large multinational companies that make use of videoconferencing and the Internet for employee training. If this rate of growth continues, the number of corporate universities will exceed the number of traditional universities by 2010. A parallel development in business is the growth of a new breed of companies that offer online training services to small- and medium-sized enterprises.

What is telecollaboration?

Online learning involving students logging in to formal courses online is perhaps the most commonly thought of application of the Internet in education. However, it is by no means the only application. Web-based collaboration tools, such as email, listservs, message boards, real-time chat, and Web-based conferencing, connect learners to other learners, teachers, educators, scholars and researchers, scientists and artists, industry leaders and politicians—in short, to any individual with access to the Internet who can enrich the learning process.

The organized use of Web resources and collaboration tools for curriculum appropriate purposes is called telecollaboration. Judi Harris defines telecollaboration as “an educational endeavor that involves people in different locations using Internet tools and resources to work together. Much educational telecollaboration is curriculum-based, teacher-designed, and teacher-coordinated. Most use e-mail to help participants communicate with each other. Many telecollaborative activities and projects have Web sites to support them." The best telecollaborative projects are those that are fully integrated into the curriculum and not just extra-curricular activities, those in which technology use enables activities that would not have been possible without it, and those that empower students to become active, collaborative, creative, integrative, and evaluative learners (see Table 1).There are currently hundreds of telecollaborative projects being implemented worldwide and many more that have either been completed or are in development.

One example is the Voices of Youth project developed by UNICEF. It encourages students to share their views on global issues, such as HIV/AIDS and child labour, with other youth and adults around the world through an electronic discussion forum. The Voices of Youth website also provides background information on the different discussion topics as well as resource materials to help teachers integrate the Voice of Youth discussions in their other classroom activities.

The International Telementor Program (ITP) links students with mentor-experts through email and discussion forums. Founded in 1995 with support from Hewlett Packard, ITP provides project-based online mentoring support to 5th to 12th grade and university students, especially from at-risk communities. The ITP telementor typically meets online with the student at least once every two weeks to answer questions, discuss key issues, recommend useful resources, and comment on student output. The teacher's role, on the other hand, is to provide support to both student and telementor, monitor the telementoring process, and track the student's progress.

Perhaps the most widely cited telecollaborative project is the Global Learning and Observations to Benefit the Environment (GLOBE) Program. GLOBE is a U.S. Government-sponsored programme launched in 1994 that links primary and secondary students and teachers from over 10,000 schools in more than 95 countries to the scientific research community. GLOBE gives students the opportunity to collaborate with scientists in conducting earth science research. Participating students periodically take measurements of the atmosphere, water, soils, and land cover at or near their schools, following strict protocols designed by GLOBE scientists. They then enter this data to a central Web-based database. The database may be accessed by scientists, researchers and the general public. GLOBE also provides teachers with guidelines and materials for structured learning activities that take off from the students' hands-on experience. Students can also go to the GLOBE website for visualizations of the data they and other students have collected.

INFORMATION, COMMUNICATION AND TECHNOLOGY

The development of ICT (Information, Communication and Technology) has provided greater opportunities to improve the quality of education in Indonesia by increasing the quality of educators and teachers. The application of ICT in education has been one of the best solutions for teachers to make teaching and learning processes more interesting, effective and efficient. For this reason, it is essential that primary and secondary education make good use of ICT. Nowadays the term 'ICT' has been widely used in various contexts in daily life. The prevalence of cell phones and internet in the community has boosted the popularity of this term. Some magazines and tabloids about them were even published, indicating the great dependence of the community on these two forms of ICT. Taking the above facts into accounts, the government has made some relevant policies about ICT. To many, these policies seem to involve mostly technology and have little to do with information and communication. As a result, the community also becomes less involved. This should cause great concern because eventually it is the community who will be directly affected by the policies. The development of ICT and the global information infrastructure has brought significant changes in the way people live their life in many aspects . One of the important aspects that has undergone changes is education. Educators benefit a lot from ICT by using it to improve the teaching and learning process in the classroom and to support the management of education. To date, teachers have made serious attempts to incorporate the ICT into their classes, expecting betterment in learning outcomes. As a matter of fact, the application of ICT in the pursuit of knowledge at schools could be an alternative solution for them to make learning more interesting, effective and efficient . Consequently, the application of ICT in education, especially at the primary and secondary levels, has been considered indispensable. Realizing that Indonesia was left behind with respect to the use of ICT in education and this could become a vital issue in making policies about education, The Department of National Education devised a Strategic Plan about ICT in 2005. Through this Strategic Plan, The Department of National Education informed educators and teachers all over the country that the attempts to improve the quality, relevance and competitiveness of education should be made by strengthening several programs, and one of these programs was the use of ICT in education. The concrete activities to realize this program was developing ICT-based educational systems, teaching methods and instructional materials. In addition, the Department of National Education developed the information network system in schools, the infrastructure and the human resources to support the implementation of the program in education management and teaching-learning processes. Schools which implement ICT should have a clear vision on ICT use, formulate strategic goals, and plan as well as organize the use of ICT well . Additionally, the implementation of ICT in schools requires infrastructure, which is physical assets designed within a system to provide essential public services . The use of ICT in schools, however, frequently faces major obstacles which may hinder its implementation. Miller states that the challenges for schools include limited time that the teachers have, limited access, high costs, unclear vision on ICT use, lack of training and support from superiors, and inaccurate evaluation results.

In the Indonesian context the obstacles that may inhibit the implementation of ICT in the schools located in remote areas are:

(1) inefficient management of infrastructure,

(2) monopoly of the government in managing the infrastructure

(3) limited funding (especially in the initial investment).

Infrastructure is physical assets which are designed in a system to provide crucial public service, such as infrastructure of information access in education. The infrastructure should be integrated to the other systems—namely social and economic ones—in the natural environment, as depicted.

The Relationship between Infrastructure and Other Systems The infrastructures include such public facilities as roads, water systems, sewer systems, solid waste management, drainage, power plants, telecommunication, and others. One aspect of infrastructure is dependent on the others.

Some problems may arise when building the infrastructure, namely,

(1) inefficient infrastructure management,

(2) monopoly by the government in infrastructure management

(3) limited funding.

To find out the readiness of the schools in the outskirts of Malang to access educational information and make use of the information provided by the Department of National Education, it was essential to conduct a comprehensive evaluation study about it. The present study was expected to obtain empirical evidence of how far the use of the existing ICT equipment could fill the gap of information that occurred in the schools in the urban areas and those located in the outskirts.

2. Model of ICT Implementation

The development of ICT nowadays has been very fast and various aspects of life have accordingly been favorably affected. With respect to ease of use and quality, ICT has developed drastically. Despite the improvement, there have been anecdotal reports that inform the unsuccessful applications of ICT in education contexts. This fact should cause great concerns among educators and stakeholders of education.

The success of ICT applications in schools is determined by three factors, namely, hardwares, softwares and the technology user. Morgan supported the empirical evidence by arguing that applications of ICT generally yielded favorable results if the users possessed certain characteristics which prompted good behaviors supporting the use of ICT. The present study was a quantitative evaluative study, using survey as the research design. The population of the study comprised primary and secondary schools in the outskirts of Malang. Two groups of sample were drawn randomly from population. The first group of sample consisted of teachers of the schools mentioned above. One teacher was drawn randomly from each school, resulting in teachers as the sample. The second group of sample consisted of subjects. Ten students were drawn randomly from each of these schools:

elementary schools (ES),

junior high schools (JHS),

senior high schools (SHS),

and vocational high schools (VHS).

In addition, 10 members of the community (C) around the schools were drawn randomly to be included in the second group of sample. The total number of subjects in the second group was fifty. The instruments of the study were questionnaires. There was one questionnaire to collect data about ICT infrastructure from the first group of sample, and another to collect data about the users' knowledge about ICT from the second group of sample.

The data of ICT infrastructure consists of five components:

(1) hardware,

(2) software,

(3) brainware,

(4) netware,

(5) dataware.

The data of knowledge about ICT consists of three components:

(1) knowledge about computers,

(2) knowledge about internet,

(3) knowledge about Electronic School Books (ESB).

These two types of data were obtained by means of questionnaires which used five-point Likert scales with the following options: “very familiar” = 5, “familiar” = 4, “moderately familiar” = 3, “unfamiliar” = 2, and “very unfamiliar” = 1. The questionnaires were handed directly to the respondents. Before the questionnaires were administered to the respondents, a try-out was conducted to estimate the validity and the reliability of these research instruments.

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Information & Communication Technology Education (ICT Education)

Learning with Information Communication Technology (ICT) provides the essential skills necessary to operate effectively in the 21st century while providing a learning environment that is interesting and engaging. ICT education at UNE is integrated across all teaching qualifications. We have an outstanding online study program, where we provide support through podcasts, blogs and discussion forums (to name a few) to develop student-teacher interaction. On campus courses offer full interaction with staff and students in stimulating workshops and seminars related to developing skills and teaching with ICT.

ICT Education units of study are core to all UNE teaching service programs. There are two aspects to our courses and our units of study in ICT education:

- teaching about ICT; and
- teaching with ICT.

Study ICT education units in your undergraduate or postgraduate study

Whether you are a student teacher or a qualified teacher wanting to advance your skills, our priority in teacher education is to ensure you develop ICT skills for active and meaningful learning, and to learn ICT teaching and learning strategies. We encourage you to be confident and creative in your approach to using ICT in your classroom. As a pre-service teacher, you are required to participate in professional experience (practice teaching) in schools to deliver effective teaching and learning activities that employ ICTs to achieve your students' learning outcomes.

Our focus is that graduate teachers meet the Australian Institute for Teaching and School Leadership (AITSL) Professional Teaching Standards, and have achieved the mandatory requirements developed by the NSW Board of Studies, Teaching and Educational Standards, namely:

- an understanding of the underlying pedagogical assumptions of ICT, eg gender and ethnic bias, educational relevance, social impact, suitability for the classroom environment, for cooperative learning and for peer interaction;
- consideration of the issues of appropriate access to, and verification of,information gained from a variety of sources including the Internet;

- an understanding of innovation in information and communication technologies and their potential for enhancing student learning;
- a developed awareness of the range of applications and adaptive technologies available to support students with special needs;
- an evaluation of ICT-based learning materials and software for educational purposes;
- an effective employment ICT applications to support specific syllabus outcomes, content and processes;
- developed skills to design a range of ICT-based assessment tasks employing marking criteria clearly linked to syllabus outcomes;
- an understanding of the requirements that they and their students use electronic information appropriately including in relation to plagiarism, copyright, censorship and privacy;
- a developed capacity to employ software to construct texts, manipulate images, create presentations, generate digital sound and visual sequences, store and retrieve digital information for classroom and on-line learning;
- a demonstrated a capacity to critically evaluate, retrieve, manipulate and manage the information from sources such as the Internet, CDs, DVDs and other commercial programs;

- a successful use of software that supports social networks and communication including email, forums, chat and list services; and
- a developed capacity to use appropriate software for student profiling and reporting, lesson preparation and class/faculty administration.

The ICT Education team have many years of classroom experience. We encourage you to be confident and creative in your approach to using ICT in your classroom. ICT lecturers actively carry out research into learning with ICT. This research directly informs the education programs. If you already have a completed degree with a major in IT, complete the Master of Teaching (Secondary) to attain your teaching qualification. ICT Education is also offered to students wishing to upgrade from a 3-year teaching qualification.

INFORMATİON ABOUT COMPUTER GRAPHİCS. COMPUTER GRAPHİCS. RASTER GRAPHİCS. COMPUTER GRAPHİCS. VECTOR GRAPHİCS. COMPUTER GRAPHİCS. FRACTAL GRAPHİCS

Computer graphics means drawing pictures on a computer screen. What's so good about that? Sketch something on paper—a man or a house—and what you have is a piece of analog information: the thing you draw is a likeness or analogy of something in the real world. Depending on the materials you use, changing what you draw can be easy or hard: you can erase pencil or charcoal marks easily enough, and you can scrape off oil paints and redo them with no trouble; but altering watercolors or permanent markers is an awful lot more tricky. That's the wonder of art, of course—it captures the fresh dash of creativity—and that's exactly what we love about it.

But where everyday graphics is concerned, the immediacy of art is also a huge drawback. As every sketching child knows too well, if you draw the first part of your picture too big, you'll struggle to squeeze everything else on the page.... and what if you change your mind about where to put something or you want to swap red for orange or green for blue? Ever had one of those days where you rip up sheet after sheet of spoiled paper and toss it in the trash?

That's why many artists, designers, and architects have fallen in love with computer graphics. Draw a picture on a computer screen and what you have is a piece of digital information. It probably looks similar to what you'd have drawn on paper—the ghostly idea that was hovering in your mind's eye to begin with—but inside the computer your picture is stored as a series of numbers. Change the numbers and you can change the picture, in the blink of an eye or even quicker. It's easy to shift your picture around the screen, scale it up or down, rotate it, swap the colors, and transform it in all kinds of other ways.

Once it's finished, you can save it, incorporate it into a text document, print it out, upload it to a web page, or email it to a client or work colleague—all because it's digital information. (Find out more about the benefits of digital in our main article about analog and digital.)

Raster and vector graphics

All computer art is digital, but there are two very different ways of drawing digital images on a computer screen, known as raster and vector graphics. Simple computer graphic programs like Microsoft Paint and Paint Shop Pro are based on raster graphics, while more sophisticated programs such as Corel DRAW, AutoCAD, and Adobe Illustrator use vector graphics. So what exactly is the difference?

Raster graphics

Stare hard at your computer screen and you'll notice the pictures and words are made up of tiny colored dots or squares called pixels. Most of the simple computer graphic images we come across are pixelated in this way, just like walls are built out of bricks. The first computer screens, developed in the mid-20th century, worked much like televisions, which used to build up their moving pictures by "scanning" beams of electrons (tiny charged particles inside atoms, also called cathode rays) back and forth from top to bottom and left to right—like a kind of instant electronic paintbrush. This way of making a picture is called raster scanning and that's why building up a picture on a computer screen out of pixels is called raster graphics.

Photo: Raster graphics: This is a closeup of the paintbrushes in the photo of the artist's paint palette up above. At this magnification, you can clearly see the individual colored pixels (squares) from which the image is built, like bricks in a wall.

Bitmaps

You've probably heard of binary, the way that computers represent decimal numbers (1,2,3,4 and so on) using just the two digits zero and one (so the decimal number 5678 becomes 1011000101110 in binary computer speak). Suppose you're a computer and you want to remember a picture someone is drawing on your screen. If it's in black and white, you could use a zero to store a white area of the picture and a one to store a black area (or vice versa if you prefer). Copying down each pixel in turn, you could transform a picture filling an entire screen of, say, 800 pixels across by 600 pixels down into a list of 480,000 (800 x 600) binary zeros and ones. This way of turning a picture into a computer file made up of binary digits (which are called bits for short) is called a bitmap, because there's a direct correspondence—a one-to-one "mapping"—between every pixel in the picture and every bit in the file. In practice, most bitmaps are of colored pictures. If we use a single bit to represent each pixel, we can only tell whether the pixel is on or off (white or black); if we use (say) eight bits to represent each pixel, we could remember eight different colors, but we'd need eight times more memory (storage space inside the computer) to store a picture the same size. The more colors we want to represent, the more bits we need.

Raster graphics are simple to use and it's easy to see how programs that use them do their stuff. If you draw a pixel picture on your computer screen and you click a button in your graphics package to "mirror" the image (flip it from left to right or right to left), all the computer does is reverse the order of the pixels by reversing the sequence of zeros and ones that represent them. If you scale an image so it's twice the size, the computer copies each pixel twice over (so the numbers 10110 become 1100111100) but the image becomes noticeably more grainy and pixelated in the process. That's one of the main drawbacks of using raster graphics: they don't scale up to different sizes very well. Another drawback is the amount of memory they require. A really detailed photo might need 16 million colors, which involves storing 24 bits per pixel and 24 times as much memory as a basic black-and-white image. (Do the sums and you'll find that a picture completely filling a 1024 x 768 computer monitor and using 24 bits per pixel needs roughly 2.5 megabytes of memory.)

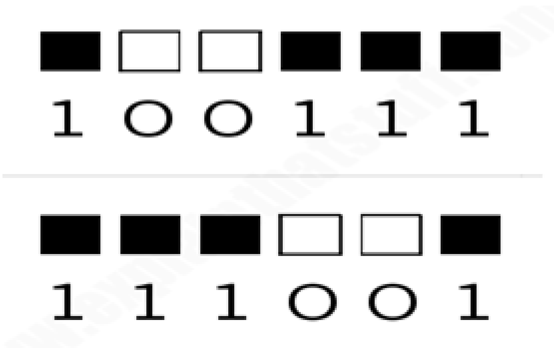


Photo: How a raster graphics program mirrors an image. Top: The pixels in the original image are represented by zeros and ones, with black pixels represented here by 1 and white ones represented by zero. That means the top image can be stored in the computer's memory as the binary number 100111. That's an example of a very small bitmap. Bottom: Now if you ask the computer to mirror the image, it simply reverses the order of the bits in the bitmap, left to right, giving the binary number 111001, which automatically reverses the original pattern of pixels. Other transformations of the picture, such as rotation and scaling, involve swapping the bits in more complex ways.

Resolution

The maximum number of pixels in an image (or on a computer screen) is known as its resolution. The first computer I ever used properly, a Commodore PET, had an ultra-low resolution display with 80 characters across by 25 lines down (so a maximum of 2000 letters, numbers, or punctuation marks could be on the screen at any one time); since each character was built from an 8 × 8 square of pixels, that meant the screen had a resolution of 640 × 200 = 128,000 pixels (or 0.128 Megapixels, where a Megapixel is one million pixels). The laptop I'm using right now is set to a resolution of 1280 × 800 =1.024 Megapixels, which is roughly 7–8 times more detailed. A digital camera with 7 Megapixel resolution would be roughly seven times more detailed than the resolution of my laptop screen or about 50 times more detailed than that original Commodore PET screen.

Anti-aliasing

Displaying smoothly drawn curves on a pixelated display can produce horribly jagged edges ("jaggies"). One solution to this is to blur the pixels on a curve to give the appearance of a smoother line. This technique, known as anti-aliasing, is widely used to smooth the fonts on pixelated computer screens.

Photo: How anti-aliasing works: Pixelated images, like the word "pixelated" shown here, are made up of individual squares or dots, which are really easy for raster graphics displays (such as LCD computer screens) to draw. I copied this image directly from the italic word "pixelated" in the text up above. If you've not altered your screen colors, the original tiny text probably looks black and very smooth to your eyes. But in this magnified image, you'll see the letters are actually very jagged and made up of many colors. If you move back from your screen, or squint at the magnified word, you'll see the pixels and colors disappear back into a smooth black-and-white image. This is an example of anti-aliasing, a technique used to make pixelated words and other shapes smoother and easier for our eyes to process.

Vector graphics

There's an alternative method of computer graphics that gets around the problems of raster graphics. Instead of building up a picture out of pixels, you draw it a bit like a child would by using simple straight and curved lines called vectors or basic shapes (circles, curves, triangles, and so on) known as primitives. With raster graphics, you make a drawing of a house by building it from hundreds, thousands, or millions of individual pixels; importantly, each pixel has no connection to any other pixel except in your brain. With vector graphics, you might draw a rectangle for the basic house, smaller rectangles for the windows and door, a cylinder for the smokestack, and a polygon for the roof. Staring at the screen, a vector-graphic house still seems to be drawn out of pixels, but now the pixels are precisely related to one another—they're points along the various lines or other shapes you've drawn. Drawing with straight lines and curves instead of individual dots means you can produce an image more quickly and store it with less information: you could describe a vector-drawn house as "two red triangles and a red rectangle (the roof) sitting on a brown rectangle (the main building)," but you couldn't summarize a pixelated image so simply. It's also much easier to scale a vector-graphic image up and down by applying mathematical formulas called algorithms that transform the vectors from which your image is drawn. That's how computer programs can scale fonts to different sizes without making them look all pixelated and grainy.

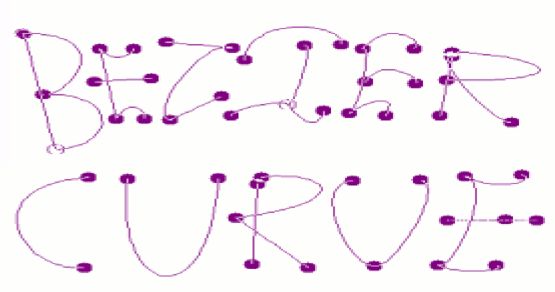


Photo: Vector graphics: Drawing with Bézier curves ("paths") in the GIMP. You simply plot two points and then bend the line running between them however you want to create any curve you like.

Most modern computer graphics packages let you draw an image using a mixture of raster or vector graphics, as you wish, because sometimes one approach works better than another—and sometimes you need to mix both types of graphics in a single image. With a graphics package such as the GIMP (GNU Image Manipulation Program), you can draw curves on screen by tracing out and then filling in "paths" (technically known as Bézier curves) before converting them into pixels ("rasterizing" them) to incorporate them into something like a bitmap image.

3D graphics

Real life isn't like a computer game or a virtual reality simulation. The very best CGI (computer-generated imagery) animations are easy to tell apart from ones made on film or video with real actors. Why is that? When we look at objects in the world around us, they don't appear to be drawn from either pixels or vectors. In the blink of an eye, our brains gather much more information from the real-world than artists can include in even the most realistic computer-graphic images. To make a computerized image look anything like as realistic as a photograph (let alone a real-world scene), we need to include far more than simply millions of colored-in pixels.

Really sophisticated computer graphics programs use a whole series of techniques to make hand-drawn (and often completely imaginary) two-dimensional images look at least as realistic as photographs. The simplest way of achieving this is to rely on the same tricks that artists have always used—such things as perspective (how objects recede into the distance toward a "vanishing point" on the horizon) and hidden-surface elimination (where nearby things partly obscure ones that are further away).

If you want realistic 3D artwork for such things as CAD (computer-aided design) and virtual reality, you need much more sophisticated graphic techniques. Rather than drawing an object, you make a 3D computer model of it inside the computer and manipulate it on the screen in various ways. First, you build up a basic three-dimensional outline of the object called a wire-frame (because it's drawn from vectors that look like they could be little metal wires). Then the model is rigged, a process in which different bits of the object are linked together a bit like the bones in a skeleton so they move together in a realistic way. Finally, the object is rendered, which involves shading the outside parts with different textures (surface patterns), colors, degrees of opacity or transparency, and so on. Rendering is a hugely complex process that can take a powerful computer hours, days, or even weeks to complete.

Sophisticated math is used to model how light falls on the surface, typically using either ray tracing (a relatively simple method of plotting how light bounces off the surface of shiny objects in straight lines) or radiosity (a more sophisticated method for modeling how everyday objects reflect and scatter light in duller, more complex ways).

Photo: NASA scientists think computer graphics will one day be so good that computer screens will replace the cockpit windows in airplanes.

Instead of looking at a real view, the pilots will be shown a computerized image drawn from sensors that work at day or night in all weather conditions.

For now, that remains a science fiction dream, because even well-drawn "3D" computer images like this are easy to tell from photographs of real-world scenes: they simply don't contain enough information to fool our amazingly fantastic eyes and brains. Photo courtesy of NASA Langley Research Center (NASA-LaRC).

What is computer graphics used for?

Photo: Computer graphics can save lives.

Medical scan images are often complex computerized images built up from hundreds or thousands of detailed measurements of the human body or brain. Photo by courtesy of Warren Grant

Magnuson Clinical Center (CC) and US National Institutes of Health (NIH).

Obvious uses of computer graphics include computer art, CGI films, architectural drawings, and graphic design—but there are many non-obvious uses as well and not all of them are "artistic." Scientific visualization is a way of producing graphic output from computer models so it's easier for people to understand. Computerized models of global warming produce vast tables of numbers as their output, which only a PhD in climate science could figure out; but if you produce a speeded-up animated visualization—with the Earth getting bluer as it gets colder and redder as it gets hotter—anyone can understand what's going on. Medical imaging is another good example of how graphics make computer data more meaningful.

When doctors show you a brain or body scan, you're looking at a computer graphic representation drawn using vast amounts of data produced from thousands or perhaps even millions of measurements.

The jaw-dropping photos beamed back from space by amazing devices like the Hubble Space Telescope are usually enhanced with the help of a type of computer graphics called image processing; that might sound complex, but it's not so very different from using a graphics package like Google Picasa or Photo Shop to touch up your holiday snaps).

And that's really the key point about computer graphics: they turn complex computer science into everyday art we can all grasp, instantly and intuitively.

Back in the 1980s when I was programming a Commodore PET, the only way to get it to do anything was to type meaningless little words like PEEK and POKE onto a horribly unfriendly green and black screen.

Virtually every modern computer now has what's called a GUI (graphical user interface), which means you operate the machine by pointing at things you want, clicking on them with your mouse or your finger, or dragging them around your "desktop."

It makes so much more sense because we're visual creatures: something like a third of our cortex (higher brain) is given over to processing information that enters our heads through our eyes. That's why a picture really is worth a thousand words (sometimes many more) and why computers that help us visualize things with computer graphics have truly revolutionized the way we see the world.

What is computer-aided design (CAD)?

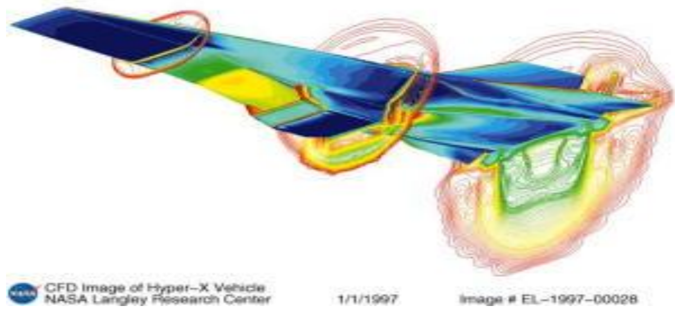


Photo: Designing a plane? CAD makes it quicker and easier to transfer what's in your mind's eye into reality. Photo by courtesy of NASA Langley Research Center (NASA-LaRC).

Computer-aided design (CAD)—designing things on a computer screen instead of on paper—might sound hi-tech and modern, but it's been in use now for over a half century. It first appeared back in 1959, when IBM and General Motors developed Design Augmented by Computers-1 (DAC-1), the first ever CAD system, for creating automobiles on a computer screen.

Drawing on a computer screen with a graphics package is a whole lot easier than sketching on paper, because you can modify your design really easily. But that's not all there is to CAD. Instead of producing a static, two-dimensional (2D) picture, usually what you create on the screen is a three-dimensional (3D) computer model, drawn using vector graphics and based on a kind of line-drawn skeleton called a wireframe, which looks a bit like an object wrapped in graph paper.

Once the outside of the model's done, you turn your attention to its inner structure. This bit is called rigging your model (also known as skeletal animation). What parts does the object contain and how do they all connect together? When you've specified both the inside and outside details, your model is pretty much complete. The final stage is called texturing, and involves figuring out what colors, surface patterns, finishes, and other details you want your object to have: think of it as a kind of elaborate, three-dimensional coloring-in. When your model is complete, you can render it: turn it into a final image. Ironically, the picture you create at this stage may look like it's simply been drawn right there on the paper: it looks exactly like any other 3D drawing. But, unlike with an ordinary drawing, it's super-easy to change things: you can modify your model in any number of different ways. The computer can rotate it through any angle, zoom in on different bits, or even help you "cutaway" certain parts (maybe to reveal the engine inside a plane) or "explode" them (show how they break into their component pieces).

What is CAD used for?

From false teeth to supercars and designer dresses to drink cartons, virtually every product we buy today is put together with the help of computer-aided design. Architects, advertising and marketing people, draftsmen, car designers, shipbuilders, and aerospace engineers—these are just some of the people who rely on CAD. Apart from being cheaper and easier than using paper, CAD designs are easy to send round the world by email (from designers in Paris to manufacturers in Singapore, perhaps). Another big advantage is that CAD drawings can be converted automatically into production instructions for industrial robots and other factory machines, which greatly reduces the overall time needed to turn new designs into finished products. Next time you buy something from a store, trace it back in your mind's eye: how did it find its way into your hand, from the head-scratching designer sitting at a computer in Manhattan to the robot-packed factory in Shanghai where it rolled off the production line? Chances are it was all done with CAD!

Using CAD in architecture

Photo: Architectural models are traditionally made from paper or cardboard, but they're laborious and expensive to make, fragile and difficult to transport, and virtually impossible to modify. Computer models don't suffer from any of these drawbacks. Photo by Warren Gretz courtesy of US DOE/NREL.

Architects have always been visionaries—and they helped to pioneer the adoption of CAD technology from the mid-1980s, when easy-to-use desktop publishing computers like the Apple Mac became widely available. Before CAD came along, technical drawing, was the best solution to a maddening problem architects and engineers knew only too well: how to communicate the amazing three-dimensional constructions they could visualize in their mind's eye with clarity and precision. Even with three-dimensional drawings (such as orthographic projections), it can still be hard to get across exactly what you have in mind. What if you spent hours drawing your proposed building, airplane, or family car... only for someone to say infuriating things like: "And what does it look like from behind? How would it look from over there? What if we made that wall twice the size?" Having drawn their projections, architects would typically build little models out of paper and board, while engineers would whittle model cars and planes out of balsa wood. But even the best models can't answer "What if...?" questions.

Computer-aided design solves these problems in a particularly subtle way. It doesn't simply involve drawing 2D pictures of buildings on the screen: what you produce with CAD is effectively a computer model of your design. Once that's done, it's easy to rotate your design on-screen or change any aspect of it in a matter of moments. If you want to make a wall twice the size, click a button, drag your mouse here and there, and the computer automatically recalculates how the rest of your model needs to change to fit in. You can print out three dimensional projections of your model from any angle or you can demonstrate the 3D form to your clients on-screen, allowing them to rotate or play with the model for themselves. Some models even let you walk through them in virtual reality. CAD has revolutionized architecture not simply by removing the drudge of repetitive plan drawing and intricate model making, but by providing a tangible, digital representation of the mind's eye: what you see is—finally—what you get.

Over the last 30 years, computers have absolutely revolutionized architecture. In 2012, Architects' Journal went so far as to describe CAD as "the greatest advance in construction history."

Who invented computer graphics?

Here's a brief timeline of some key moments in the history of computer graphics. In this section, most links will take you to Wikipedia articles about the pioneering people and programs.

Photo: A NASA scientist draws a graphic image on an IBM 2250 computer screen with a light pen. This was state-of-the-art technology in 1973! Photo by courtesy of NASA Ames Research Center (NASA-ARC).

- 1951: Jay Forrester and Robert Everett of Massachusetts Institute of Technology (MIT) produce Whirlwind, a mainframe computer that can display crude images on a television monitor or VDU (visual display unit).
- 1955: Directly descended from Whirlwind, MIT's SAGE (Semi-Automatic Ground Equipment) computer uses simple vector graphics to display radar images and becomes a key part of the US missile defense system.

- 1959: General Motors and IBM develop Design Augmented by Computers-1 (DAC-1), a CAD (computer-aided design) system to help engineers design cars.
- 1961: John Whitney, Sr. uses computer graphics to design a captivating title sequence for the Alfred Hitchcock thriller Vertigo.
- 1961: MIT student Steve Russell programs Spacewar!, the first graphical computer game, on a DEC PDP-1 minicomputer.
- 1963: Ivan Sutherland, a pioneer of human-computer interaction (making computers intuitively easy for humans to use), develops Sketchpad (also called Robot Draftsman), one of the first computer-aided design packages, in which images can be drawn on the screen using a light pen (an electronic pen/stylus wired into the computer). Later, Sutherland develops virtual reality equipment and flight simulators.
- 1965: Howard Wise holds an exhibition of computer-drawn art at his pioneering gallery in Manhattan, New York.
- 1966: NASA's Jet Propulsion Laboratory (JPL) develops an image-processing program called VICAR (Video Image Communication and Retrieval), running on IBM mainframes, to process images of the moon captured by spacecraft.
- 1970: Bézier curves are developed, soon becoming an indispensable tool in vector graphics.

- 1972: Atari releases PONG, a popular version of ping-pong (table tennis) played by one or two players on a computer screen.
- 1973: Richard Shoup produces SuperPaint, a forerunner of modern computer graphic packages, at the Xerox PARC (Palto Alto Research Center) laboratory.
- 1970s: Ivan Sutherland's student Edwin Catmull becomes one of the pioneers of 3D computer-graphic animation, later playing key roles at Lucasfilm, Pixar, and Disney.
- 1981: UK company Quantel develops Paintbox, a revolutionary computer-graphic program that allows TV producers and filmakers to edit and manipulate video images digitally.
- 1982: The movie Tron, starring Jeff Bridges, mixes live action and computer graphic imagery in a story that takes a man deep inside a computer system.
- 1980s: The appearance of the affordable, easy-to-use Apple Macintosh computer paves the way for desktop publishing (designing things on your own small office computer) with popular computer graphic packages such as Aldus PageMaker (1985) and QuarkXPress (1987).
- 1985: Microsoft releases the first version of a basic raster-graphics drawing program called MS Paint. Thanks to its stripped-down simplicity, it becomes one of the world's most popular computer art programs.

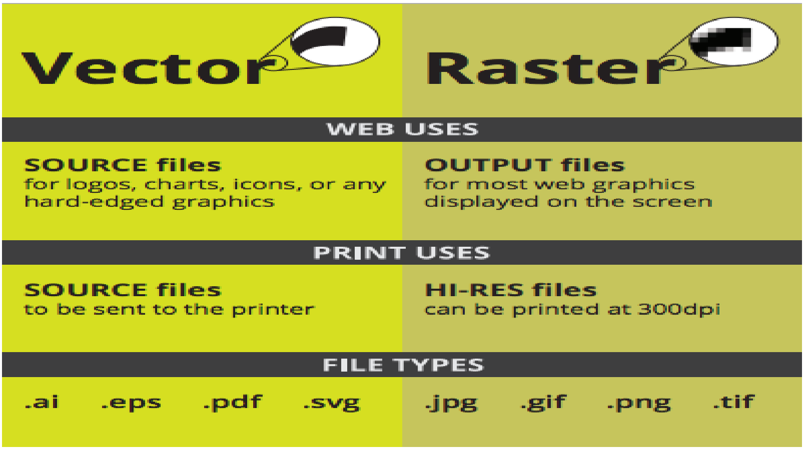
- 1990: The first version of Adobe PhotoShop (one of the world's most popular professional graphic design packages) is released. A simple, affordable home graphics program called PaintShop (later PaintShop Pro) is launched the same year.
- 1993: University of Illinois student Marc Andreessen develops Mosaic, the first web browser to show text and images side-by-side, prompting a huge explosion in interest in the Web virtually overnight.
- 1995: Toy Story, produced by Pixar Animation Studios (founded by Apple's Steve Jobs, with Ed Catmull as its chief technology officer) demonstrates the impressive possibilities of CGI graphics in moviemaking. Stunning follow-up movies from the same stable include A Bug's Life, Monsters, Inc., Finding Nemo, and The Incredibles.
- 1995: The GIMP (GNU Image Manipulation Program) is developed by University of California students Spencer Kimball and Peter Mattis as an open-source alternative to PhotoShop..
- 1999: The World Wide Web Consortium (W3C) begins development of SVG (Scalable Vector Graphics), a way of using text-based (XML) files to provide higher-quality images on the Web. SVG images can include elements of both conventional vector and raster graphics.

- 2007: Apple launches its iPhone and iPod Touch products with touchscreen graphical user interfaces.
- 2017: Microsoft announces it will not kill off its basic but very popular Paint program, loved by computer artists for over 30 years.

If you're confused over the difference between the many image file types, you're not alone. When starting off a project, one of the first things we request from the client is a vector file of their logo. However, that request is often met with blank stares or responses like "can't you just pull the logo from my site?". As a marketer, understanding the importance and role of different image file types is essential to ensuring your brand is properly represented and to better communicate with designers, developers and printers.

WHAT IS A VECTOR FILE? WHAT IS RASTER?

We can start making sense of the issue by clarifying the difference between the two major image types – raster and vector.



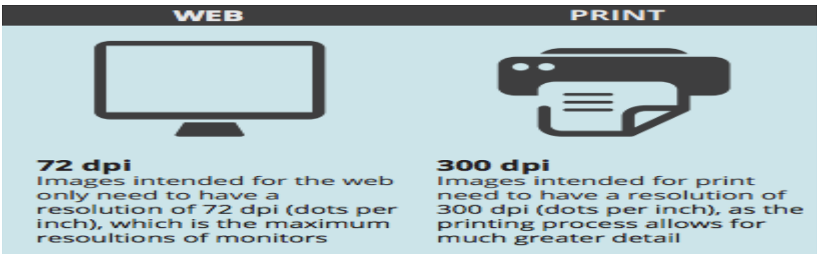
Raster images use many colored pixels or individual building blocks to form a complete image. JPEGs, GIFs and PNGs are common raster image types. Almost all of the photos found on the web and in print catalogs are raster images.

Because raster images are constructed using a fixed number of colored pixels, they can't be dramatically resized without compromising their resolution. When stretched to fit a space they weren't designed to fill, their pixels become visibly grainy and the image distorts. This is why altered photos may appear pixilated or low resolution. Therefore, it is important that you save raster files at precisely the dimensions needed to eliminate possible complications.

Vector images, alternatively, allow for more flexibility. Constructed using mathematical formulas rather than individual colored blocks, vector file types such as EPS, AI and PDF* are excellent for creating graphics that frequently require resizing. Your company logo and brand graphics should be created as a vector and saved as a master file so you can use it with smaller items such as your business card and letterhead, but also on larger surfaces, such as your corporate jet. When necessary, always create a JPG or PNG for use on the web from this master vector file. Just be sure to save the new raster file in the exact dimensions needed.

***A PDF is generally a vector file.** However, depending how a PDF is originally created, it can be either a vector or a raster file. Whether you opt to flatten the layers of your file or choose to retain each one will determine the image type.

HIGH RESOLUTION OR LOW RESOLUTION?



To determine whether your raster images are a suitable resolution for a specific application, you need to check their pixel density. Units of measurement such as dots per inch (DPI) or pixels per inch (PPI) refer to the number of pixels in one inch of the image. These measurements become important when you attempt to use raster images in specific places, such as on the web or in print publications.

The web, historically, displays 72dpi (72 dots or pixels per inch) – a relatively low pixel density however most modern displays are now much higher. That said many images on the web are still in that 72-100 dpi range. While monitors can display higher resolution the web also needs to optimized for speed so images around 100 dpi hit the sweet spot for looking great on a screen but also loading quickly. Raster images with a low DPI in the 72-100 look nice and crisp on the web. But this same low DPI image may not be suitable for printing on a brochure or packaging. To correctly print an image, it should be at least 300dpi, a much higher pixel density than the web displays.

Resizing a low DPI image pulled from the web to fit the dimensions of your print project won't work because the same finite number of pixels only get bigger and begin to distort. For example, let's say you want to print your logo at 2″x3″ on a brochure. If have a 72dpi jpg of your logo and it's 2-inches by 3-inches, it will need to be "stretched" to more than 3 times the size to get it up to 300dpi. That 72dpi logo may look great on your computer monitor, but when it prints at 300dpi it will look pixilated. Instead you should use a vector version of your logo (.EPS or .AI) or create a raster (JPG) with the exact dimensions desired and at 300dpi.

DIFFERENT IMAGE FILE EXTENSION TYPES AND THE BEST USE FOR EACH

JPG

JPG (or JPEG) is a raster image that is often used for photographs on the web. JPGs can be optimized, when saving them out of photoshop, to find the perfect balance of small file size and high quality. On the web, you want your images files to be as small as they can be so your site loads quickly, but large enough to still appear crisp and not pixilated. A JPG can't have a transparent background so they are always in the shape of a rectangle or square with a solid background.

Best use = rectangle or square photos and photographs on your website.

PNG

PNG is another raster image type. For the general marketer, the main difference to understand between a PNG and JPG is that a PNG can have a transparent background and is generally larger and higher quality. Therefore a PNG is ideal for saving logo files for websites because they can be placed over a colored background.

Best use = logos, icons and other images where a transparent background is preferred.

GIF

A GIF is another raster image type. A GIF is formed from up to 256 colors from the RBG colorspace. The fewer colors and shades contained in an image, the smaller the file size. Therefore a GIF is ideal for images that use just a few solid colors and don't have gradients or natural shades. You wouldn't want to use a GIF for a photograph.

Best use = simple web graphics such as web buttons, charts and icons.

TIF

A TIF (or TIFF) is a large raster file. It has no loss in quality and therefore is primarily used for images used in printing. On the web, because of load time, you generally want to use smaller images such as JPG or PNG.

Best use = images and photographs for high quality print.

EPS

An EPS file is a vector file of a graphic, text or illustration. Because it is vector it can easily be resized to any size it needs to be. An EPS file can be reopened and edited.

Best use = master logo files and graphics and print designs.

AI

An AI file is a proprietary, vector file type created by Adobe that can only be created or edited with Adobe Illustrator. It is most commonly used for creating logos, illustrations and print layouts.

Best use = creating logos, graphics, illustrations.

Editing vector files and saving "in outlines"

Vector files such as AI and EPS can remain editable so you can open them back up in Illustrator and edit any text or other elements within the graphic. With images that contain text that are saved as a JPG, PNG or GIF, you would not be able to reopen and edit the text.

At MODassic we often create files in Illustrator and save an AI file as our master file, but then also save an EPS version, "in outlines" which is used in production and sent to print.

Saving in "outlines" is a term that you will hear when sending files to print. If a printer doesn't have a font you used in your design and the vector file is not saved in outlines then when they open the file the text won't have the desired look as it will default to a different font. Saving something with "outlines" basically means you are locking the text so that it's no longer technically a font but instead made up of vector shapes that form your letters. This is important when sending graphics to print. Saving a file in outlines makes your text no longer editable which is why at MODassic we keep the AI file as an editable master and then save an EPS as the locked final artwork which we send to print.

Working with images can be confusing, but bearing these key facts in mind will eliminate much of the hassle and of course we're always here to help or answer any questions.

the word "fractal" often has different connotations for the lay public as opposed to mathematicians, where the public are more likely to be familiar with fractal art than the mathematical concept. The mathematical concept is difficult to define formally, even for mathematicians, but key features can be understood with little mathematical background.

The feature of "self-similarity", for instance, is easily understood by analogy to zooming in with a lens or other device that zooms in on digital images to uncover finer, previously invisible, new structure. If this is done on fractals, however, no new detail appears; nothing changes and the same pattern repeats over and over, or for some fractals, nearly the same pattern reappears over and over. Self-similarity itself is not necessarily counter-intuitive (e.g., people have pondered self-similarity informally such as in the infinite regress in parallel mirrors or the homunculus, the little man inside the head of the little man inside the head ...). The difference for fractals is that the pattern reproduced must be detailed.

This idea of being detailed relates to another feature that can be understood without much mathematical background: Having a fractal dimension greater than its topological dimension, for instance, refers to how a fractal scales compared to how geometric shapes are usually perceived. A straight line, for instance, is conventionally understood to be one-dimensional; if such a figure is rep-tiled into pieces each 1/3 the length of the original, then there are always three equal pieces. A solid square is understood to be two-dimensional; if such a figure is rep-tiled pieces each scaled down by a factor of 1/3 in both dimensions, there are a total of $3^2 = 9$ pieces. We see that for ordinary self-similar objects, being n-dimensional means that when it is rep-tiled into pieces each scaled down by a scale-factor of 1/r, there are a total of r^n pieces. Now, consider the Koch curve. It can be rep-tiled into four sub-copies, each scaled down by a scale-factor of 1/3. So, strictly by analogy, we can consider the "dimension" of the Koch curve as being the unique real number D that satisfies $3^D = 4$. This number is what mathematicians call the fractal dimension of the Koch curve; it is certainly not what is conventionally perceived as the dimension of a curve (this number is not even an integer!). The fact that the Koch curve has a fractal dimension differing from its conventionally understood dimension (that is, its topological dimension) is what makes it a fractal.

This also leads to understanding a third feature, that fractals as mathematical equations are "nowhere differentiable". In a concrete sense, this means fractals cannot be measured in traditional ways. To elaborate, in trying to find the length of a wavy non-fractal curve, one could find straight segments of some measuring tool small enough to lay end to end over the waves, where the pieces could get small enough to be considered to conform to the curve in the normal manner of measuring with a tape measure. But in measuring an infinitely "wiggly" fractal curve such as the Koch snowflake, one would never find a small enough straight segment to conform to the curve, because the jagged pattern would always re-appear, at arbitrarily small scales, essentially pulling a little more of the tape measure into the total length measured each time one attempted to fit it tighter and tighter to the curve. The result is that one must need infinite tape to perfectly cover the entire curve, i.e. the snowflake has infinite perimeter.

Fractal patterns have been modeled extensively, albeit within a range of scales rather than infinitely, owing to the practical limits of physical time and space. Models may simulate theoretical fractals or natural phenomena with fractal features. The outputs of the modelling process may be highly artistic renderings, outputs for investigation, or benchmarks for fractal analysis. Some specific applications of fractals to technology are listed elsewhere. Images and other outputs of modelling are normally referred to as being "fractals" even if they do not have strictly fractal characteristics, such as when it is possible to zoom into a region of the fractal image that does not exhibit any fractal properties. Also, these may include calculation or display artifacts which are not characteristics of true fractals.

Modeled fractals may be sounds, digital images, electrochemical patterns, circadian rhythms, etc. Fractal patterns have been reconstructed in physical 3-dimensional space and virtually, often called "in silico" modeling. Models of fractals are generally created using fractal-generating software that implements techniques such as those outlined above. As one illustration, trees, ferns, cells of the nervous system, blood and lung vasculature, and other branching patterns in nature can be modeled on a computer by using recursive algorithms and L-systems techniques. The recursive nature of some patterns is obvious in certain examples—a branch from a tree or a frond from a fern is a miniature replica of the whole: not identical, but similar in nature. Similarly, random fractals have been used to describe/create many highly irregular real-world objects. A limitation of modeling fractals is that resemblance of a fractal model to a natural phenomenon does not prove that the phenomenon being modeled is formed by a process similar to the modeling algorithms.

INTRODUCTION TO WINDOWS

INTRODUCTION TO WINDOWS Microsoft Windows Operating System

All computers and computer like devices have operating systems, including your laptop, tablet, desktop, Smartphone, smart watch, router etc. Windows is operating system from Microsoft Inc. It is a system program that controls, coordinates and manipulates overall desktop publishing operations. It serves as an interface between the hardware and other software on the computer system. It allocates memory locations to data and other computer programs. It controls other computer resources like files and programs, input/output devices, computer memories etc during data processing operations. It also performs the hardware and software diagnosis to detect faults and errors. Versions of windows Windows provides a graphical user interface (GUI), and support many peripheral devices. In addition to windows operating system for personal computers, Microsoft also offers operating system for servers and personal computers.

1. Windows 1.0- 2.0 (1985-1992). Window 1.0 allowed users to point and click to access the windows. Window 2.0 added icons, keyboard shortcuts and improved graphics.

2. Windows 3.0-3.1 (1990-1994). Support better icons and program manager (1st version of “look and feel” screen of Microsoft windows).

3. Windows 95 (August 1995). It runs faster and has ability to automatically delete and configure installed hardware (plug and play).

4. Windows 98 (June 1998). It offers supports for new technology FAT32, AGP, MMX, USB, DVD. It is an active desktop which integrates the web browser (internet Explorer).

5. Windows ME- Millennium Edition (September 2000). Booting is in Dos option.

6. Windows NT 3.1-4.0 (1993-1996). It supports pre-emptive multi tasking.

7. Windows 7 (October 2009). Improved performance and start-up-time and window media centre.

8. Windows 8 (August 2012). It was developed with touch screen use in mind. Better startup. Start screen replaced look and feel screen made up of “live Tiles”

9. Windows 10 (2015). Fast start-up, Microsoft edge, Microsoft new browser.

10. Window server (2003). Designed for corporate networking, internet/intranet, hosting, data bases and similar functions.

11. Window Home Server (January 2007). This is a "consumer Server" designed to use with multiple computers connected in the home. Aside from window operating system designed for personal computers (PCs) and laptops, Microsoft has also developed operating system for services, handheld devices and mobile phones.

1. **Window CE** (November 2006) it is designed for small devices such as PDAs for handheld computing devices.

2. **Windows mobile** (April 2000) designed for smart phones and mobile devices.

3. **Windows phone 7-10** (November 2010) or win phone 7 designed for smart phones and mobile devices but targeted more to the consumer market than enterprises market. Major Features of Windows The following are the attributes and characteristics of reliable windows:

1. **Interactive Package**: It ensures a flow of communication between the user and the computer. Hence, it serves as an intermediary between the two parties.
2. **Menu Driven Package**: Ms-Windows ensure flexibility in that the user can perform several functions or task without remembering the commands, simply by the Click. Of an option of a menu or sub-menu.

3. **Program Manager**: Ms-Window serves as a manager to other programs since it controls, co-ordinates and manipulates their processing.
4. **Multi-tasking Package**: With windows operations, a user can make use of two or more package while shifting from one package to another e.g. A user can be working in ms-excel, and at the same time involve in PageMaker etc. Appearance of Window Screen The appearance of window screen depends on how the computer is being set-up.

A window screen always contains various items or ICON depending on the window version. Hence, a reliable window screen consists of the following: major icons and other additional icons.

1. **My computer Icon**: This is a container for disk drives. My computer icon displays window with Icons representing object in the computer system. Such as folder, files, disk-drive.
2. **Internet Explorer**: This is a shortcut for launching the internet explorer program, which is web browser. A web browser is a software program for navigating, WWW (World Wide Web).
3. **Network Neighbourhood**: Network neighbourhood icon serves as container for network resources of other, computer

it might include items such as; disk drive, printer and CD-ROMS.

4. **Network**: A network is a collection of several computer connected together with the aim of sharing the same resources and component e.g. printer.
5. **Recycle Bin**: This is a computer object for files that are no longer needed the computer or, this is a temporary storage location where all files are kept. One can retrieve such file if deleted by error.

Different versions of windows Window Screens The windows' screen consists of several icons arranged according' to the computer set up the user. Icons: An icon is an image or picture representing a particular function on the window's screen. It is like a command or instruction to perform a particular task. Some of the icons noticed on the window screen a computer, network neighbourhoods,

Recycle Bin, Internet Explorer, Start and Tune button. To access an icon, double click on such, and window responds by displaying the operation under the icon. Accessing Windows When a computer system is switch on, the memory tent is performed until the window screen appears automatically. Window screen is divided into two parts; the upper layer which contains several icons and the lower layer called the status /bar which contain the: start button, task bar and time. Status Bar: This is the lower part of the windows. It consists' of the start button, task bar and time. Start Button: it contain everything needed to work with windows, start icon of the windows consists of several options in form of sub-menu.

Hence, when you click on start button, a supmenu appears as follows:

1. Program: it displays the list of software available in the windows environment for the user to utilize.
2. Document: it displays the list of documents that have been opened previously.
3. Setting: it list out all the computer components which their setting can be changed e.g. setting date and time, changing window screen etc.
4. Find: it is used to find and locate a particular file, folder and e-mail messages.
5. Help: it shows the steps involve in performing a particular task. It equally serves as a tutor.
6. Run: it is mainly used to run or execute Ms-command and other application packages.
7. Shut Down: it is used to shut down or re-start the computer.

It should be noted that the system must be properly shut down before switching off the system. Task Bar Each time an operation is performed, a button representing that window appears on the task bar. To switch from the window to another click on the button for the window you want in the task bar. Notification Area It shows at the extreme end of the status bar. It displays the current time. Folder A folder is a directory, which stores files and other folders. Or a folder is a directory through which users can access files and other folders. Windows Operating Devices These are electronic devices used in manipulating windows. It could be input device or output device.

Input Device

An input device is a peripheral (piece of computer hardware equipment) used in sending in data, control signals and graphics to the computer memory or any other information processing system allowing you to interact with and control the computer. They include keyboard, mouse scanner, joystick, light pen etc.

1. **Computer Keyboard**: it is a rectangular tray of electronic keys used as input device to send data, instructions, commands and signals into the computer. It is the 'primary computer input unit device. It consists of several types of keys: Function Keys: F1-F12 Alphabetic Keys: A-Z,. Numeric Keys: 0-9 Control Keys: Alt key {}, Ctrl key, Fn key etc Editing Keys: End, Spacebar, Backspace, Caps Lock, Del key etc. Directional/Navigating Keys: the arrow keys, Pg Up and PgDn and Keys, Home and

End keys. Special Function Keys: Ctrl+A, insert, Numlock, PrtSc etc. Special Character Keys: I, / @, “, #, !, &,%,*,(),{}, [], :, ;, -, +, =, etc.

2. **Mouse**: this is a rat-like pointing device used as input device to send command to the computer by point, click and drag operations. Mouse could be an optical mouse or rolling ball mouse, a PS/2 mouse, a Serial mouse or the padded (as found on laptops PDAs).
3. **Scanner**: this is a graphic puts service that sends graphics, picture, and images to the computer memory for processing. It consists of tubes light that takes the picture of an object and send it to the memory for processing. Computer Keyboards A keyboard is the most fundamental input device for any computer system. In the early days of computing, it was typically the only input device. Keyboard is one of the input devices that used to transfer data, from outside world into the CPU. As you type, the processor in the keyboard analyzes the key matrix and determines what characters to send to the computer.

It maintains three characters in its memory buffer and then sends the data.

1. Typical keyboard for desktop computer
2. Typical laptop computer

Many keyboards connect to the computer through a cable with a PS/2 or USB (Universal Serial Bus) connector. Laptops use internal connectors. Regardless of which types of, connector is used, the cable must carry power to the keyboard, and it must carry signals from the keyboard back to the computer. Wireless keyboards, on the other hand connect to the computer through infrared (IR), radio frequency (RF) Bluetooth connections. IR and RF connections are similar to what you will find in a remote control.

Regardless of which sort of signal they use, wireless keyboards require a receiver, either built in or plugged in to the USB port, to communicate with the computer. Since they don't have a physical connection to the computer, wireless keyboards have an AC power connection or use batteries for power. Microsoft Wireless Keyboard Microsoft Wireless Keyboard is a battery-powered computer keyboard. Whether it's through a cable or wireless, the signal from the keyboard is monitored by the computer's keyboard controller. This is an integrated circuit (IC) that processes all of the data that comes from the keyboard and forwards it to the operating system. When the operating system (OS) is notified that there is data from the keyboard it checks to see if the keyboard data is a system level, command (i.e. command that controls the computer system itself, a good example of this is Ctrl-Alt-Delete on a Windows computer, which reboots the system). If it is not a system level command, then, the OS passes the keyboard data on to the current application.

The application also determines whether the keyboard data is a command like Alt-F, which opens the file menu in a windows application. If the data is not a command, the application accepts it as content, which can be anything from typing a document to entering a URL to performing a calculation. If the current application does not accept keyboard data it simply ignores the information. This whole process, from pressing the key to entering content into application, happens almost instantaneously.

The mouse Mouse Techniques

These are the modes of using mouse. They include:

1. **Pointing**: this is a process of making the mouse pointer touch an option or icon on a window screen during selection of an object or option.
2. **Clicking**: this is a process of pointing the mouse pointer at the option or icon and instantly presses the left right button to select an option.
3. **Dragging**: this is a process of holding down the left button and move the mouse along the mouse pad and release when desired.
4. **Double clicking**: it is a process of pressing the button on two consecutive times i.e. we double click to see the content of an

icon. Typical mouse Mouse innovations As with many computer-related devices, mouse is being combined with other gadgets and technologies to create improved and multipurpose devices.

Examples include multi- media mouse, combination mouse/remote controls, optical mouse, gaming mouse, biometric mouse, tilting wheel mouse and motion-based mouse. To learn more about innovations in mouse technology, let's start with multi-media mouse and combination mouse/remote controls. Multi-media Mouse and Combination Mouse/Remote These types' of mouse are used with multimedia systems such the windows XZ media Center Edition computers. Some combine features of a mouse with additional as buttons (such as play, pause; forward, back and volume) for controlling media. Others resemble a television/media player remote control with added features for mousing. Remote controls generally use infrared sensor but some use a combination of infrared and RF technology for greater range. Gaming Mouse Gaming Mouse are high-pressure, optical mouse designed for use and game controllers. Its features may include: Multiple buttons for added flexibility and functions such as adjusting (dots per inch) rates on the fly. Wireless connectivity and an optical sensor. Motion feedback and two-way communication Motion Based Mouse Yet another innovation in mouse technology is motion-based control feature, you control the mouse pointer by waving the mouse in the air. Biometric Mouse Biometric Mouse adds security to your computer system by permitting-authorized users to control the mouse and access the computer.

Pro' accomplished with an integrated fingerprint reader either in the receiver or the mouse. This feature enhances security and adds convenience because-can use your fingerprint rather than passwords for a secure login. The Wireless Intellimouse Explorer with Fingerprint Reader is a Biome to use the biometric features, a software program that comes with registers fingerprints and stores information about corresponding users. Some software programs also let you encrypt and decrypt files. keyboard track pads on a laptop computer Desktop computers have a separate keyboard and mouse, but for laptops, these are integrated into a computer system itself. In laptops, the mouse is actually substituted with a touch pad or track pad. You can still connect an external mouse to a laptop if you prefer. Computer flatbeds scanners. Another common input device is an image scanner.

A typical desktop or flatbed scanner is a device that optically scans printed images and paper documents and converts them into digital images. Microphone. Audio and video can be recorded using a microphone and video camera, respectively. Due to the popularity of video conference on Skpe, these are typically integrated in most laptops and monitor displays for desktops; however, you can also connect an external webcam, which can record both audio and video. Input devices The most commonly used or primary input devices in a computer are the keyboard and mouse. However, there are dozens of other devices that can also be used to input data into the computer.

Below is a list of computer input devices that can be utilized with a computer or a computing device.

1. Touch screen
2. Webcam.
3. Audio conversion device.
4. Barcode reader.
5. Finger print scanner.
6. Business card reader.
7. Digital camera and digital camcorder.
8. Gamepad, Joystick, Paddle.
9. Gesture recognition.
10. Graphics tablet.
11. Light gun and light pen scanner.
12. Magnetic stripe reader.
13. Microphone (using voice speech recognition or biometric verification).
14. Touch pad or other pointing device.

15. Optical mark reader (OMR).

16. Light pen or stylus.

17. Punch card reader.

18. Video capture device.

QUESTIONS

1. List 5 input devices apart from the keyboard, mouse and scanner.

2. What does an input device send to a computer?

3. What is the difference between an input device and output device?

4. What is window operating system

5. List 3 types of window operating system with date and major features.

6. What is the difference between status bar and task bar.

Microsoft Windows Operating System

All computers and computer like devices have operating systems, including your laptop, tablet, desktop, Smartphone, smart watch, router etc. Windows is operating system from Microsoft Inc. It is a system program that controls, coordinates and manipulates overall desktop publishing operations. It serves as an interface between the hardware and other software on the computer system.

It allocates memory locations to data and other computer programs. It controls other computer resources like files and programs, input/output devices, computer memories etc during data processing operations. It also performs the hardware and software diagnosis to detect faults and errors.

Versions of windows Windows provides a graphical user interface (GUI), and support many peripheral devices. In addition to windows operating system for personal computers, Microsoft also offers operating system for servers and personal computers. 1. Windows 1.0- 2.0 (1985-1992). Window 1.0 allowed users to point and click to access the windows. Window 2.0 added icons, keyboard shortcuts and improved graphics. 2. Windows 3.0-3.1 (1990-1994). Support better icons and program manager (1st version of "look and feel" screen of Microsoft windows). 3. Windows 95 (August 1995). It runs faster and has ability to automatically delete and configure installed hardware (plug and play). 4. Windows 98 (June 1998). It offers supports for new technology FAT32, AGP, MMX, USB, DVD. It is an active desktop which integrates the web browser (internet Explorer). 5. Windows ME- Millennium Edition (September 2000). Booting is in Dos option. 6. Windows NT 3.1-4.0 (1993-1996). It supports pre-emptive multi tasking.

They are Windows NT and Windows NT SERVER. 7. Windows 2000 or W2k. (February 2000). It is an operating system for business desktop and laptop systems to run software applications. 8. Windows XP (October 2001). It has a better look and feel. There are two versions Home and professional. 9. Windows Vista (November 2006). It offered an advancement in reliability, security and ease of deployment. 10. Windows 7 (October 2009). Improved performance and start-up-time and window media centre. 11. Windows 8 (August 2012). It was developed with touch screen use in mind. Better startup. Start screen replaced look and feel screen made up of "live Tiles" 12. Windows 10 (2015). Fast start-up, Microsoft edge, Microsoft new browser. 13. Window server (2003). Designed for corporate networking, internet/intranet, hosting, data bases and similar functions. 14. Window Home Server (January 2007). This is a "consumer Server" designed to use with multiple computers connected in the home. Aside from window operating system designed for personal computers (PCs) and laptops, Microsoft has also developed operating system for services, handheld devices and mobile phones.

1. Window CE (November 2006) it is designed for small devices such as PDAs for handheld computing devices.

2. Windows mobile (April 2000) designed for smart phones and mobile devices.

3. Windows phone 7-10 (November 2010) or win phone 7 designed for smart phones and mobile devices but targeted more to the consumer market than enterprises

Network Neighbourhood: Network neighbourhood icon serves as container for network resources of other, computer it might include items such as; disk drive, printer and CD-ROMS. (iv) Network: A network is a collection of several computer connected together with the aim of sharing the same resources and component e.g. printer.

Recycle Bin: This is a computer object for files that are no longer needed the computer or, this is a temporary storage location where all files are kept. One can retrieve such file if deleted by error. Fig. 7.1: Different versions of windows Window Screens The windows' screen consists of several icons arranged according' to the computer set up the user. Icons: An icon is an image or picture representing a particular function on the window's screen.

It is like a command or instruction to perform a particular task. Some of the icons noticed on the window screen a computer, network neighbourhoods, Recycle Bin, Internet Explorer, Start and Tune button. To access an icon, double click on such, and window responds by displaying the operation under the icon. Accessing

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Desktop computers have a separate keyboard and mouse, but for laptops, these are integrated into a computer system itself. In laptops, the mouse is actually substituted with a touch pad or track pad. You can still connect an external mouse to a laptop if you prefer. Computer flatbeds scanners. Another common input device is an image scanner. A typical desktop or flatbed scanner is a device that optically scans printed images and paper documents and converts them into digital images. Microphone. Audio and video can be recorded using a microphone and video camera, respectively. Due to the popularity of video conference on Skpe, these are typically integrated in most laptops and monitor displays for desktops; however, you can also connect an external webcam, which can record both audio and video.

Input devices

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9. Gesture recognition.
10. Graphics tablet.
11. Light gun and light pen scanner.
12. Magnetic stripe reader.

13. Microphone (using voice speech recognition or biometric verification).

14. Touch pad or other pointing device.

15. Optical mark reader (OMR).

16. Light pen or stylus.

17. Punch card reader.

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QUESTIONS

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WINDOWS ACCESSORIES

USING WINDOWS XP CALCULATOR

Like a calculator you keep in a desk drawer, the Windows Calculator is small but saves you time by performing all the calculations common to a standard calculator.

The Standard Windows Calculator, works so much like a pocket calculator that you need little help getting started.

To display the Calculator, open the Start menu and choose Programs, Accessories, Calculator. The Calculator opens in the same view (Standard or Scientific) in which it was displayed the last time it was used.

To close the Calculator, click the Close button in the title bar. If you use the Calculator frequently, however, don't close it; click the Minimize button to minimize the Calculator to a button on the taskbar.

The Calculator has only three menus: Edit, View, and Help. The Edit menu contains two simple commands for copying and pasting; the View menu switches between the Standard and Scientific views; and the Help menu is the same as in all Windows accessories.

Operating the Calculator

To use the Calculator with the mouse, just click the appropriate numbers and sign keys, like you would press buttons on a desk calculator. Numbers appear in the display window as you select them, and the results appear after the calculations are performed. To enter numbers from the keyboard, use either the numbers across the top of the keyboard or those on the numeric keypad (you must first press the NumLock key if the NumLock feature is not enabled). To calculate, press the keys on the keyboard that match the Calculator keys.

NOTE: To calculate a percentage, treat the % key like an equal sign. For example, to calculate 15 percent of 80, type 80*15%. After you press the % key, the Calculator displays the result (in this case, 12).

2. Using Windows XP Notepad

Notepad is a miniature text editor. Just as you use a notepad on your desk, you can use Notepad to take notes onscreen while working in other Windows applications.

Because Notepad stores files in text format, almost all word processing applications can retrieve Notepad's files. However, if you want the capability of formatting your documents, you'll need a true word processor.

Starting Notepad

To start Notepad, open the Start menu and choose Programs, Accessories, Notepad. Notepad starts up and displays a blank document in the Notepad window (see Figure 15.1). You can begin typing.

Working with Documents in Notepad

You can move the insertion point by using either the mouse or the keyboard. You select and edit text in Notepad the same way you select and edit text in WordPad. See "Selecting and Editing Text" later in the chapter for details.

Limited formatting is available from the File, Page Setup command.

You can change margins and add a header or footer, but you cannot format characters or paragraphs in any way. You also can use the Tab, Spacebar, and Backspace keys to align text. Tab stops are preset at every eight characters.

With the commands on Notepad's Edit menu, you can cut, copy, and move text from one place in a file to another.

Text that you cut or copy is stored in the Clipboard. When you paste text, the contents of the Clipboard is copied from the Clipboard to the document at the location of the insertion point.

Explore the following two Windows XP Accessories on your own.

3. Using Windows XP WordPad

Word Pad is the word processor that comes with Windows XP that can perform most basic word processing tasks. Although it is not nearly as powerful and versatile as a full-featured word processing application (such as Microsoft Word XP), it is much more powerful than Notepad, the text editor that comes with Windows XP.

Creating a New Document in WordPad

WordPad is located in the Accessories submenu of the Start menu.

To start WordPad, open the Start menu and choose Programs, Accessories, WordPad. The WordPad window appears.

When you first open WordPad, you are presented with a blank document.

Using Windows XP Paint

Paint is n easy-to-learn graphics application that you can use to create and modify graphics images.

Starting Windows Paint

To start Paint, click Start, Programs, Accessories, Paint. Paint starts up and opens a new, empty Paint file.

Learn to Use Paint

To learn how to use this application, from the Menu Bar, click on the

Help Menu | Help Topics | Paint

Various accessories can be summarized as –

Calculator:

The Windows XP calculator is a great addition. Essentially, it is Windows calculator, which has a number of options. For example, there is a standard calculator and a scientific calculator, which has a many more calculations and includes four types of numbers.

Notepad:

Essentially Notepad is a basic word processor where notes can be added. It is indeed very limited and has only a few options limited to fonts, but is suitable for taking notes. However, do not consider Notepad as a potential alternative to Word or Office Suite Writer, because it is not.

Paint:

Paint is art software that comes with Windows XP. Overall, it has a few options for painting, such as brushes, text and shapes. However, even for freeware it is a limited art package.

Address book:

The Windows XP address book is another of its accessories. This is an address book, where various names and addresses can be added. There are a few record options included here, including name, business and personal. Details can then be added and removed from the address book. The address book also includes a search option, to search records added.

Microsoft Paint

Microsoft Paint (formerly **Paintbrush**, not to be confused with a Mac Os X application) is a simple raster graphics editor that has been included with all versions of Microsoft Windows. The program opens and saves files in Windows bitmap (BMP), JPEG, GIF, PNG, and single-page TIFF formats. The program can be in color mode or two-color black-and-white, but there is no grayscale mode. For its simplicity and that it is included with Windows, it rapidly became one of the most used applications in the early versions of Windows, introducing many to painting on a computer for the first time. It is still widely used for simple image manipulation tasks.

In July 2017, Microsoft added Paint to the list of deprecated Windows features and announced that it would become a free standalone application in the Microsoft Store, and also included a warning in the Paint application that it eventually won't be installed by default. However, Paint continued to be included with Windows 10 in later builds, and eventually an update removed the deprecation warning from the application.

MICROSOFT WORD

LIST OF MICROSOFT WINDOWS COMPONENTS

CONFIGURATION AND MAINTENANCE

Component	Description	Introduced
Settings		Windows 8
Control Panel		
Control Panel	Allows users to view and change basic system settings and controls, such as adding hardware, adding and removing software, controlling user accounts, and	Windows 1.0

	changing accessibility options	
Device Manager	Allows the user to display and control the hardware attached to the computer, and control what device drivers are used	Windows 95
Windows Mobility Center	Centralizes the most relevant information related to mobile computing	Windows Vista
Security and Maintenance	Centralizes and reports on the status of anti-virus, Automatic Updates, Windows Firewall, and other security-related components of the operating system	Windows XP SP2
Administrative Tools		

Microsoft Management Console	Provides system administrators and advanced users with a flexible interface through which they may configure and monitor the system	Windows NT 4.0 Option Pack
Windows System Assessment Tool	Built-in benchmarking tool that analyzes the different subsystems (graphics, memory, etc.), and uses the results to allow for comparison to other Windows Vista systems, and for software optimizations. It rates the computer's performance using the Windows Experience Index.	Windows Vista
System Restore	Allows for the rolling back of system files, registry keys, installed apps, etc., to a previous	Windows Me

	state in the event of a system failure	
Windows Recovery Environment	Helps diagnose and recover from serious errors which may prevent Windows from booting successfully, or restore the computer to a previous state using System Restore or a backup image	Windows Vista
Microsoft Drive Optimizer	Rearranges files stored on a hard disk to occupy contiguous storage locations in order to optimize computer performance	Windows 95, Windows 2000
Event Viewer	Lets administrators and users view the event logs on a local or remote machine	Windows NT 3.1

Resource Monitor (previously Reliability and Performance Monitor)	Lets administrators view current system reliability and performance trends over time	Windows Vista
Logical Disk Manager	Logical volume manager developed by Microsoft in conjunction with Veritas Software	Windows NT 4.0 (Separate Tool), Windows 2000
Registry Editor	Allows users to browse and edit the Windows registry	Windows 3.1
Task Scheduler	Allows users to script tasks for running during scheduled intervals	Microsoft Plus! for Windows 95
Software installation and deployment		
Windows Update	An online service providing updates such as service packs, critical	Windows 98

	updates and device drivers. A variation called Microsoft Update also provides software updates for other Microsoft products.	
Windows Installer	An engine for the management of software installation. Includes a GUI framework, automatic generation of the uninstallation sequence and deployment capabilities for corporate networks.	Windows 2000
ClickOnce	Technology for deploying .NET Framework-based software via web pages, with automatic update capabilities. Intended for per-user only applications.	.NET Framework 2.0

User interface

Component	Description	Introduced
Action Center		Windows 10Version 1507
Windows PowerShell	Command-line shell and scripting framework.	Windows XP
Windows Shell	The most visible and recognizable aspect of Microsoft Windows. The shell provides the container inside of which the entire graphical user interface is presented, including the taskbar, the desktop, Windows Explorer,	Windows 95

	as well as many of the dialog boxes and interface controls. In Windows Vista, a new compositing glass-like user interface called Windows Aero has been shown.	
File Explorer (previously Windows Explorer)	Provides an interface for accessing the file systems, launching applications, and performing common tasks such as viewing and printing pictures	Windows 95
Windows Search	Starting with Windows Vista,	Windows Vista,

	search is a tightly shell-integrated component of Windows. A downloadable Windows Desktop Search software is available for Windows XP and older versions.	downloadable for older versions
Search Folders	Virtual folders that retrieve items based on queries rather than hierarchical folder trees on disk.	Windows Vista
Special Folders	Folders which are presented to the user through an interface as an abstract concept, instead of an absolute path. This	Windows 95

	makes it possible for an application to locate where certain kinds of files can be found, regardless of what version or language of operating system is being used. See also Windows Shell namespace.	
Start menu	Serves as the central launching point for applications. It provides a customizable, nested list of apps for the user to launch, as well as a list of most recently opened documents, a way to find files	Windows 95

	and get help, and access to the system settings. By default, the Start Button is visible at all times in the lower left-hand corner of the screen.	
Taskbar	The application desktop bar which is used to launch and monitor applications	Windows 1.0
Task View		Windows 10Version 1507
File associations	Used to open a file with the appropriate app. Users can assign file associations uniquely to specific	Windows 1.0

	actions, known as verbs.	

Applications and utilitie

Component	Description	Introduced
Easy Transfer	Used to transfer many files at once from one computer to another	Windows Vista
Contacts	Keeps a single list of contacts that can be shared by multiple apps	Windows Vista
Camera		Windows 8
Calculator	Calculation application	Windows 1.0
Calendar	Calendaring application	Windows Vista
Character Map	Utility to view and search characters in a font, copy them to the clipboard and view	Windows 3.1

	their Windows Alt keycodes and Unicode names	
Cortana	Digital personal assistant	Windows 10 Version 1507
Edge	Web browser	Windows 10 Version 1507
Feedback Hub	Platform for exchanging communication with Windows Insiders and developers	Windows 10 Version 1607
Groove Music (previously Xbox Music)	Digital media player and media library application that is used for playing audio. In addition to being a media player, Groove includes the ability to copy music to compact discs, synchronize content with a digital audio player (MP3 player) or other mobile devices, and let users	Windows 8

	purchase or rent music from the Windows Store.	
Movies & TV (previously Xbox Video)	Digital media player and media library application that is used for playing video. In addition to being a media player, Movies & TV lets users purchase or rent movies and TV episodes from the Windows Store.	Windows 8
OneDrive (previously SkyDrive)	Freemium cloud storage folder and sync service	Windows 8.0
OneNote	Integrated note-taking app, based on the Microsoft Office product of the same name	Windows 10 Version 1507
On-Screen	Virtual keyboard	

Keyboard (osk.exe)		
Paint	Simple graphics painting app	Windows 1.0
Paint 3D	Simple graphics painting app	Windows 10 Version 1703
Photos	Simple image viewer	Windows 8
Steps Recorder (called Problem Steps Recorder in Windows 7)		Windows 7

Windows To Go	Utility to create bootable versions of Windows 8 and above	Windows 8
Notepad	Simple text editor	Windows 1.0
Narrator	Screen reader utility that reads dialog boxes and window controls in a number of the more basic applications for Windows	Windows 2000
Sound Recorder	Simple audio recording app that can record from a microphone or headset, and save the results in WAVE format and Windows Media Audio format in some Windows versions	Windows 3.0 Multimedia Extensions
Skype	Messaging and calling service	Windows 8.1, downloadable for

		previous versions
Sticky Notes	Tool for jotting notes on the desktop	Windows XP Tablet PC Edition
Command Prompt	Text-based shell (command line interpreter) that provides a command line interface to the operating system	Windows NT 3.1
WordPad	Simple word processor that is more advanced than Notepad. It has facilities to format and print text, but lacks intermediate features such as a spell checker and thesaurus.	Windows 95
Private Character Editor	Utility to create private use characters as defined under Unicode and various East Asian encoding schemes	Windows 3.1 East Asian editions
Remote Desktop	Client implementation of the Remote Desktop Protocol;	Windows XP,

Connection	allows a user to securely connect to a computer running Terminal Services (Remote Desktop on Windows XP and Server 2003) and interact with a full desktop environment on that machine, including support for remoting of printers, audio, and drives.	downloadable for previous Windows versions
Remote Assistance	Allows a user to temporarily take over a remote computer over a network or the internet to offer help with and resolve issues	Windows XP
Mobility Center	Allows a user to adjust settings related to mobile computing	Windows Vista
Speech Recognition	Allows a user to input voice commands	Windows Vista
Internet Explorer	Web browser and FTP client. See also: Internet Explorer	Microsoft Plus! for

	versions, Features, History, Removal, Browser Helper Objects	Windows 95
IExpress	Allows users to create self-extracting, self-installing INF installation-based packages	Internet Explorer 6
Xbox Console Companion (previously Xbox and Xbox Games)	Account manager for Xbox Live user accounts and a screen recording tool	Windows 8
Xbox Game Bar		Windows 10 May 2019 Update (Version 1903)[1]

Magnifier	Screen enlargement app	Windows 98
Fax and Scan	Integrated faxing and image scanning application	Windows Vista, older faxing and scanning applications were present in previous Windows versions
Windows Media Player	Digital media player and media library application that is used for playing audio, playing video and viewing images. In addition to being a media player, Windows Media Player includes the ability to rip music from, and copy music to compact	Downloadable for Windows 95, Windows NT 4.0 and Windows 98

	discs, synchronize content with a digital audio player (MP3 player) or other mobile devices, and let users purchase or rent music from a number of online music stores.	
Photo Viewer	Simple image viewer that can play a simple slideshow	Windows 7
Mail	Email aggregator	Windows 8.0
Maps	Map viewer that allows users to look for locations, plan routes, and store offline maps	Windows 8
Media Center	Designed to serve as a home-entertainment hub, to be viewed from a distance up to 3 meters (~10 feet) and controlled by specially designed remote controls. Lets users browse and view pictures, videos, and music from local	Windows XP Media Center Edition

	hard drives, optical drives, and network locations, along with viewing, recording and deferred-playing live TV. Features an interactive TV guide with scheduled recording capabilities. Can also be used for visualization of other information (like sports scores) within the interface.	
Task Manager	Provides information about computer performance and displays details about running applications, processes, network activity, logged-in users, and system services	Windows 3.0
Disk Cleanup	Utility for compacting rarely used files and removing files that are no longer required	Windows 98
Snipping Tool	Screen-capture tool that allows for taking screenshots (called snips)	Experience Pack for Windo

		ws XPTablet PC Edition 2005
Microsoft Store (previously Windows Store)	Initially known as Windows Store, it started as an app store for Windows 8. In Windows 10, it expanded into a broad digital distribution platform for apps, games, music, digital video and e-books. In 2017, it was renamed Microsoft Store and started offering hardware in United States, Canada and United Kingdom.	Windows 8
MSN apps	Provide information from MSN web services	Windows 8
Alarms & Clock(pr	App that allows Windows users to set alarms, stopwatches, timers, and view a world clock	Windows 8

e Alarms)		
Windows Security (previously Windows Defender Security Center)		Windows 10 Version 1703
Solitaire Collection	Set of solitaire card games	Windows 10 Version 1507

Windows Server components

Component	Description	Supported by

Active Directory	A set of technologies introduced with Windows 2000 that allows administrators to assign enterprise-wide policies, deploy apps to many computers, and apply critical updates to an entire organization. Active Directory stores information and settings relating to an organization in a central, organized, accessible database. Networks can vary from a small installation with a few objects, to global-scale directories with millions of objects. Related topics: Domain controller, Flexible single master operation	Windows 2000and later server versions

Group Policy	Provides centralized management of user and computer settings in an Active Directory environment. Group policy can control a target object's registry, NTFS securit y, audit and security policy, software installation, logon/logoff script s, folder redirection, and Internet Explorer settings. Policy settings are stored in Group Policy Objects (GPOs), and may be linked to one or more sites, domains or organizational units. Related topics: Administrative Templates	Windows 2000and later
Internet Informatio n Services	Web server	Windows NT family

File systems

Component	Description	Supported by
FAT12, FAT16	The original file systems used with MS-DOS. The standard file systems used with Windows 1.0 through Windows 95.	All versions
FAT32	Extensions to FAT supporting larger disk sizes. The standard file system for Windows 98 and Me.	Windows 95 OSR2 and later versions
NTFS	Standard file system of Windows NT; supports security	Windows NT (all versions)

	via access control lists, as well as file system journaling and file -system metadata. Windows 2000 added support for reparse points (making NTFS junction points and Single instance storage possible), Hard links, file compression, and Sparse files. Encryption of data is provided by Encrypting File System. Symbolic links and	

	transactioning of file operations via Transactional NTFS are features new to Windows Vista. Although Windows 9x operating systems cannot read or write NTFS formatted disks, they can access the data over a network if it is shared by a computer running Windows NT.	
ISO 9660 (CDFS)	The predominant file system for CD-ROM and DVD-	MS-DOS and Windows 9x via extensions, such

	ROM media. Windows includes support for Joliet extensions and the ISO 9660:1999 standard. ISO 9660:1999 is supported since Windows XP.	as MSCDEX.EXE (Microsoft CDROM Extension), natively in Windows NT
Universal Disk Format(UDF)	A file system for storing files on optical media. It is an implementation of the **ISO/IEC 13346** standard (also known as **ECMA-167**). It is considered to be a replacement of ISO 9660.	Windows 98, Windows 2000, Windows XP, Windows Server 2003, Windows Vista

	Successive versions of Windows have supported newer versions of UDF.	
HPFS	High-Performance File system, used on OS/2 computers. Read and write capability in Windows 95 (where it also listed network computer NTFS-formatted drives as "HPFS", even though it had no direct NTFS capabilities). HPFS write support was	Windows 95 (Read/write), Windows 98, Windows NT (read), 3.1/3.51(read/write/boot)

	dropped in Windows NT 4.0 and Windows 98, and dropped altogether shortly before the release of Windows 2000.	
ReFS	A newer file system, based on NTFS. This system adds built-in integrity checking and removes the need for chkdsk, among other features. The maximum	Windows Server 2012, Windows 8.1

	partition size is 1 YB.	

Core components

Component	Acronym	Description
Windows kernel (Windows NT) Main article: Architecture of the Windows NT operating system line		
Ntoskrnl.exe		The Windows kernel image. Provides the kernel and executive layers of the kernel architecture, and is responsible for services such as hardware virtualization, process and memory management, etc.

hal.dll	HAL	Provides and handles the interaction between software and hardware via the Hardware Abstraction Layer.
kernel32.dll		This application provides kernel operations to apps in the Win32 mode, like memory management, I/Os, process creation, etc.
Core processes (Windows NT)		
System idle process	SIP	A counter which measures how much idle capacity the CPU has at any given time. The process runs in the background and monitors processing bandwidth, occupied memory and the Windows virtual paging file.

Session Manager Subsystem	SMSS	Performs several critical boot-time operations, such as the creation of environment variables, starting CSRSS, and performing file-copy operations that were queued up from before the system was booted (pending file rename operations). During system operation, it handles Windows File Protection and the creation of logon sessions via Winlogon.
Client/Server Runtime Subsystem	CSRSS	User-mode side of the Win32 subsystem. Provides the capability for applications to use the Windows API.

Local Security Authority Subsystem Service	LSASS	Responsible for enforcing the security policy on the system. Verifies users logging on to the computer and creates security tokens.
Winlogon		Responsible for handling the secure attention key, loading the user profile on logon, and optionally locking the computer when a screensaver is running. On Windows NT systems prior to Windows Vista, Winlogon is also responsible for loading GINA libraries which are responsible collecting logon credentials from the user.

Svchost.exe		A generic host process name for services that run from dynamic-link libraries (DLLs). Several Svchost processes are typically present on a Windows machine, each running in a different security context, depending on what privileges the contained services require.	
Windows on Windowsand WOW 64	WoW	An abstraction layer that allows legacy code to operate on more modern versions of Windows; typically this means running 16-bit Windows applications on 32-bit Windows, and 32-bit applications on 64-bit Windows.	

Virtual DOS machine	NTVDM	Allows MS-DOS apps to run on Intel 80386 or higher computers when there is already another operating system running and controlling the hardware. Introduced in Windows 2.1; not available in any 64-bit edition of Windows.
System startup (Windows NT) Main articles: Windows NT Startup Process and Windows Vista Startup Process		
NTLDR, IA64ldr, Winload		The boot loader; performs basic system initialization options such as loading the hardware abstraction layer and boot-time device drivers, prior to passing control to the Windows kernel. In

		versions prior to Vista, NTLDR and IA64ldr also display menus to the user if multiple operating systems are defined in boot.ini, or if F8 is pressed.	
Recovery Console		Provides the means for administrators to perform a limited range of tasks using a command line interface, primarily to aid in recovering from situations where Windows does not boot successfully.	
ntdetect.com		Used during the boot process to detect basic hardware components that may be required during the boot process	

Windows Boot Manager		In Windows Vista and later operating systems, displays boot menus to the user if multiple operating systems are configured in the system's Boot Configuration Data.
Graphical subsystem		
Desktop Window Manager	DWM	The compositing manager introduced in Windows Vista that handles compositing and manages special effects on screen objects in a graphical user interface
Graphics Device Interface	GDI/GDI+	The kernel graphics component for representing graphical objects and transmitting them to output devices

		such as monitors and printers
Windows USER		The Windows USER component provides core user interface, messaging and visual elements

Services

Display name	Service key name	Description	Introduced
Active Directory Service	NTDS	Network Authentication Management	Windows 2000 Server
Alerter service	Alerter	Sends administrative alerts over the network to client computers, administrators and users	Windows NT

Application Layer Gateway service	ALG	Provides support for plugins that allow network protocols to pass through Windows Firewall and work behind Internet Connection Sharing	Windows 2000
Application Experience service		Processes application compatibility cache requests for applications as they launch	
Application Management	AppMgmt	Processes requests to enumerate, install, and remove applications that are installed on the computer or deployed through	Windows 2000

		an organization's network	
Background Intelligent Transfer Service	BITS	Transfers files between machines using idle network bandwidth. Used by Windows Update, Windows Server Update Services, and Systems Management Server to deliver software updates to clients, as well as by Windows Messenger.	Windows XP
Computer Browser	Browser	Crawls neighboring computers on the network and	Windows for Workgroups

		locates shared resources. One of the computers acts as the Master Browser and supplies this information to other computers designated as browsers.	
Delivery Optimization	DoSvc	A peer-to-peer distribution service that downloads Windows updates and Microsoft Store apps from the local network or Internet peers, and redistributes them to others. Can be configured	Windows 10 Anniversary Update[4]

		using either the Settings app or Group Policy. The Settings app can turn it on or off, and specify whether the service operates on the local network only, downloads from and uploads to the Internet peers as well. Group Policy allows finer control. Delivery Optimization relies on a centralized web service that does not index contents under 10 MB. Computers	

		without Internet access cannot use Delivery Optimization.	
Distributed Link Tracking	TrkWks, TrkSrv	Used to track links to files on NTFS volumes. Windows uses these services to find linked files if they are renamed or moved (locally or to another machine).	Windows 2000
Distributed Transaction Coordinator	MSDTC	Allows transactional components to be configured through COM+ by coordinating transactions that are distributed across multiple	Windows 2000 and later NT-based

		computers and/or resource managers, such as databases, message queues, file systems, and other transaction–based resource managers.	
DNS Client	DNSCache	Resolves and caches domain names (e.g. “en.wikipedia.org”) to IP addresses	Windows 2000
Event Log	EventLog	Stores and retrieves events that can be viewed in the event viewer. Part of services.exe.	Windows NT
Extensible Authentication Protocol	EAPHost	Provides EAP authentication to connecting clients	Windows 2000

Indexing Service	CISVC	Indexes contents and properties of files on local and remote computers; provides rapid access to files through flexible querying language.	Windows 2000 and later NT-based
Interactive Services Detection	UI0Detect	For compatibility; when a service-displayed user interface is detected, it gives the user an option to switch to Session0 to see it	Windows Vista
Internet Connection Sharing (ICS)	SharedAccess	When enabled, it allows other computers on the local network to access an internet connection that is	Windows 2000;[11] Windows Vista onward[12]

		available to the host computer	
Network Location Awareness	NLA	Manages network configurations and information, and notifies applications of changes	Windows XP
Network Store Interface Service	NSIS	Collects routing information of active network interfaces, shares this with other services and notifies applications of changes	Windows XP
NTLM Security Support Provider	NTLMSSP	Uses the NTLM MS-CHAP protocol to encapsulate and negotiate options	Windows NT

		in order to provide signed and sealed communication. Deprecated now in favor of Kerberos authentication.	
Peer Name Resolution Protocol	PNRPSvc	Resolves domain names using Peer Name Resolution Protocol	Windows XP
Plug and Play	PlugPlay	Enables autodetection and configuration of hardware	Windows 2000
Windows Print spooler [fr]	Spooler	Manages printer devices and moves files into memory for printing	Windows 95, Windows NT

Remote Procedure Call (RPC)	RpcSs	Provides Remote Procedure Call features via remotely accessible Named Pipes	Windows NT family
Routing and Remote Access Service	RRAS	API and server software that enables applications to administer the routing and remote-access service capabilities of the operating system, to function as a network router.	Windows 2000
Secondary Logon	SecLogon	Allows users to run apps with a different account than the one they	

		logged in with. Allows non-administrative accounts to perform administrative tasks.	
Security Accounts Manager	SamSs	Manages user account security information	Windows NT family
System Event Notification Service	SENS	Monitors system events, such as network, power, logon, logoff, terminal services session connection and disconnection, and delivers these to applications and other system components.	Windows 2000

Superfetch	SysMain	Monitors file usage patterns and boosts system speed by caching frequently accessed files to RAM	Windows Vista
Task Scheduler	Schedule	Lets users setup and schedule automated tasks	Microsoft Plus! for Windows 95
TCP/IP NetBIOS Helper	LmHosts	Enables support for NetBIOS over TCP/IP (NetBT) service and NetBIOS nam e resolution	Windows NT family
Volume Shadow Copy	VSS	Creates multiple versions of files that change. The ability to store persistent snapshots was	Windows XP

		added in Windows Server 2003.[16]	
Windows Audio	AudioSrv	Manages audio devices for Windows-based apps. Controls all audio functions.	Windows XP
Windows Error Reporting	WERSvc	Generates error logs and reports errors. On Windows Vista and later, it notifies of solutions.	Windows XP
Windows Firewall	MpsSvc	Blocks unauthorized network connections to and from the computer	Windows Vista

Windows Firewall(née Internet Connection Sharing)	SharedAccess	Provides a simple firewall feature which was introduced in Windows XP. It also shares the internet on the local network, if the internet connection sharing feature is turned on.	Windows XP only[18][19]
Windows Image Acquisition (WIA)	STISvc	Handles scanner and camera inputs	Windows Me
Windows Time	W32Time	Synchronizes the system time with external time servers. From Windows Server 2003 forward, full	Windows 2000

		and compliant NTP support is provided.	
Windows Update	WUAUServ	Provides updates for the operating system and its installed components	Windows XP
Wireless Zero Configuration	WZCSvc (XP), WLANSvc	Configures and manages 802.11 wireless adapters	Windows XP, Server 2003only
Windows Messenger service	Messenger	Allows users to send pop-up messages to other computers over the network	Windows NT family
WebClient		Enables Windows-based apps to create and interact	

		with Internet-based files	

MICROSOFT WORD VERSIONS

The first version of Microsoft Word was developed by Charles Simonyi and Richard Brodie, former Xerox programmers hired by Bill Gates and Paul Allen in 1981. Both programmers worked on Xerox Bravo, the first WYSIWYG (What You See Is What You Get) word processor. The first Word version, Word 1.0, was released in October 1983 for Xenix and MS-DOS; it was followed by four very similar versions that were not very successful. The first Windows version was released in 1989, with a slightly improved interface. When Windows 3.0 was released in 1990, Word became a huge commercial success. Word for Windows 1.0 was followed by Word 2.0 in 1991 and Word 6.0 in 1993. Then it was renamed to Word 95 and Word 97, Word 2000 and Word for Office XP (to follow Windows commercial names). With the release of Word 2003, the numbering was again year-based. Since then, Windows versions include Word 2007, Word 2010, Word 2013, Word 2016, and most recently, Word for Office 365.

In 1986, an agreement between Atari and Microsoft brought Word to the Atari ST. The Atari ST version was a translation of Word 1.05 for the Apple Macintosh; however, it was released under the name Microsoft Write (the name of the word processor included with Windows during the 80s and early 90s). Unlike other versions of Word, the Atari version was a one time release with no future updates or revisions. The release of Microsoft Write was one of two major PC applications that were released for the Atari ST (the other application being WordPerfect). Microsoft Write was released for the Atari ST in 1988.

In 2014 the source code for Word for Windows in the version 1.1a was made available to the Computer History Museum and the public for educational purposes.

Word 2016

On July 9, 2015, Microsoft Word 16 was released. Features include the tell me, share and faster shape formatting options. Other useful features include realtime collaboration, which allows users to store documents on Share Point or OneDrive, as well as an improved version history and a smart lookup tool. As usual, several editions of the program were released, including one for home and one for business.

Microsoft Word (or simply **Word**) is a word processor developed by Microsoft. It was first released on October

25, 1983 under the name Multi-Tool Word for Xenix systems. Subsequent versions were later written for several other platforms including IBM PCs running DOS (1983), Apple Macintosh running the Classic Mac OS (1985), AT&T Unix PC (1985), Atari ST (1988), OS/2 (1989), Microsoft Windows (1989), SCO Unix (1994), and mac OS (formerly OS X; 2001).

Commercial versions of Word are licensed as a standalone product or as a component of Microsoft Office, Windows RT or the discontinued Microsoft Works suite.

Origins

In 1981, Microsoft hired Charles Simonyi, the primary developer of Bravo, the first GUI word processor, which was developed at Xerox PARC. Simonyi started work on a word processor called Multi-Tool Word and soon hired Richard Brodie, a former Xerox intern, who became the primary software engineer.

Microsoft announced Multi-Tool Word for Xenix and MS-DOS in 1983. Its name was soon simplified to Microsoft Word. Free demonstration copies of the application were bundled with the November 1983 issue of PC World, making it the first to be distributed on-disk with a magazine. That year Microsoft demonstrated Word running on Windows.

Unlike most MS-DOS programs at the time, Microsoft Word was designed to be used with a mouse. Advertisements depicted the Microsoft Mouse, and described Word as a WYSIWYG, windowed word processor with the ability to undo and display bold, italic, and underlined text, although it could not render fonts. It was not initially popular, since its user interface was different from the leading word processor at the time, WordStar. However, Microsoft steadily improved the product, releasing versions 2.0 through 5.0 over the next six years. In 1985, Microsoft ported Word to the classic Mac OS (known as Macintosh System Software at the time). This was made easier by Word for DOS having been designed for use with high-resolution displays and laser printers, even though none were yet available to the general public. Following the precedents of Lisa Write and MacWrite, Word for Mac OS added true WYSIWYG features. It fulfilled a need for a word processor that was more capable than MacWrite. After its release, Word for Mac OS's sales were higher than its MS-DOS counterpart for at least four years.

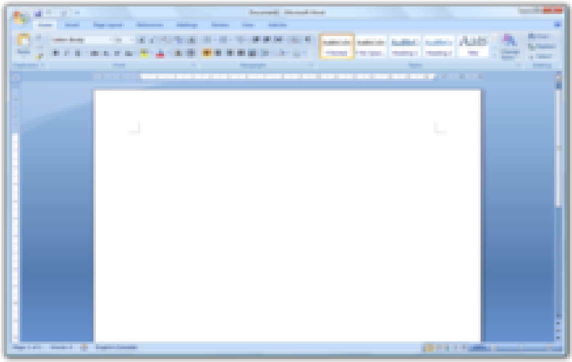
The second release of Word for Mac OS, shipped in 1987, was named Word 3.0 to synchronize its version number with Word for DOS; this was Microsoft's first attempt to synchronize version numbers across platforms. Word 3.0 included numerous internal enhancements and new features, including the first implementation of the Rich Text Format (RTF) specification, but was plagued with bugs. Within a few months, Word 3.0 was superseded by a more stable Word 3.01, which was mailed free to all registered users of 3.0. After MacWrite Pro was discontinued in the mid-1990s, Word for Mac OS never had any serious rivals. Word 5.1 for Mac OS, released in 1992, was a very popular word processor owing to its elegance, relative ease of use and feature set. Many users say it is the best version of Word for Mac OS ever created.

In 1986, an agreement between Atari and Microsoft brought Word to the Atari ST under the name Microsoft Write. The Atari ST version was a port of Word 1.05 for the Mac OS and was never updated.

The first version of Word for Windows was released in 1989. With the release of Windows 3.0 the following year, sales began to pick up and Microsoft soon became the market leader for word processors for IBM PC-compatible computers. In 1991, Microsoft capitalized on Word for Windows' increasing popularity by releasing a version of Word for DOS, version 5.5, that replaced its unique user interface with an interface similar to a Windows application. When Microsoft became aware of the Year 2000 problem, it made Microsoft Word 5.5 for DOS available for download free. As of July 2018, it is still available for download from Microsoft's web site. In 1991, Microsoft embarked on a project code-named Pyramid to completely rewrite Microsoft Word from the ground up. Both the Windows and Mac OS versions would start from the same code base. It was abandoned when it was determined that it would take the development team too long to rewrite and then catch up with all the new capabilities that could have been added in the same time without a rewrite. Instead, the next versions of Word for Windows and Mac OS, dubbed version 6.0, both started from the code base of Word for Windows 2.0.

With the release of Word 6.0 in 1993, Microsoft again attempted to synchronize the version numbers and coordinate product naming across platforms, this time across DOS, Mac OS, and Windows (this was the last version of Word for DOS). It introduced AutoCorrect, which automatically fixed certain typing errors, and AutoFormat, which could reformat many parts of a document at once. While the Windows version received favorable reviews (e.g., from InfoWorld), the Mac OS version was widely derided. Many accused it of being slow, clumsy and memory intensive, and its user interface differed significantly from Word 5.1. In response to user requests, Microsoft offered Word 5 again, after it had been discontinued. Subsequent versions of Word for mac OS are no longer direct ports of Word for Windows, instead featuring a mixture of ported code and native code.

Word for Windows



Microsoft Word 2007

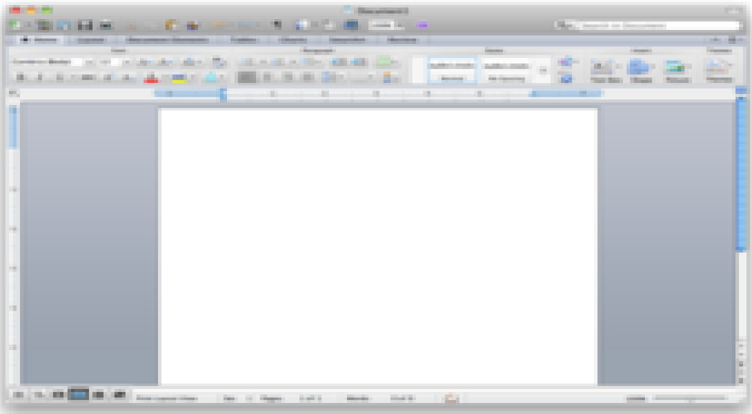
Word for Windows is available stand-alone or as part of the Microsoft Office suite. Word contains rudimentary desktop publishing capabilities and is the most widely used word processing program on the market. Word files are commonly used as the format for sending text documents via e-mail because almost every user with a computer can read a Word document by using the Word application, a Word viewer or a word processor that imports the Word format (see Microsoft Word Viewer).

Word 6 for Windows NT was the first 32-bit version of the product, released with Microsoft Office for Windows NT around the same time as Windows 95. It was a straightforward port of Word 6.0. Starting with Word 95, releases of Word were named after the year of its release, instead of its version number.

Word 2010 allows more customization of the Ribbon, adds a Backstage view for file management,[33] has improved document navigation, allows creation and embedding of screenshots, and integrates with Word Web App.

Word for Mac

The Mac was introduced January 24, 1984 and Microsoft introduced Word 1.0 for Mac a year later, January 18, 1985. The DOS, Mac, and Windows versions are quite different from each other. Only the Mac version was WYSIWYG and used a Graphical User Interface, far ahead of the other platforms. Each platform restarted their version numbering at "1.0" (https://winworldpc.com/product/microsoft-word/1x-mac). There was no version 2 on the Mac, but version 3 came out January 31, 1987 as described above. Word 4.0 came out November 6, 1990, and added automatic linking with Excel, the ability to flow text around graphics and a WYSIWYG page view editing mode. Word 5.1 for Mac, released in 1992 ran on the original 68000 CPU, and was the last to be specifically designed as a Macintosh application. The later Word 6 was a Windows port and poorly received. Word 5.1 continued to run well till the very last Classic MacOS. Many people continue to run Word 5.1 to this day under an emulated Mac classic system for some of its excellent features like document generation and renumbering or to access their old files.



Microsoft Word 2011 running on OS X

In 1997, Microsoft formed the Macintosh Business Unit as an independent group within Microsoft focused on writing software for Mac OS. Its first version of Word, Word 98, was released with Office 98 Macintosh Edition. Document compatibility reached parity with Word 97, and it included features from Word 97 for Windows, including spell and grammar checking with squiggles. Users could choose the menus and keyboard shortcuts to be similar to either Word 97 for Windows or Word 5 for Mac OS.

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Word 2011, released in October 2010, replaced the Elements Gallery in favor of a Ribbon user interface that is much more similar to Office for Windows, and includes a full-screen mode that allows users to focus on reading and writing documents, and support for Office Web Apps.

File formats

Native file formats

Left: The icon for .doc files that comes with Microsoft Office 2019. Right: The icon for .docx files, as seen on Microsoft OneDrive. The icon seen in Microsoft Office 2019 is slightly more colorful.

DOC	Legacy Word document
DOT	Legacy Word templates
WBK	Legacy Word document backup
DOCX	XML Word document
DOCM	XML Word macro-enabled document
DOTX	XML Word template
DOTM	XML Word macro-enabled template
DOCB	XML Word binary document

Filename extensions

Microsoft Word's native file formats are denoted either by a .doc or .docx filename extension.Although the .doc extension has been used in many different versions of Word, it actually encompasses four distinct file formats:

1. Word for DOS
2. Word for Windows 1 and 2; Word 3 and 4 for Mac OS
3. Word 6 and Word 95 for Windows; Word 6 for Mac OS
4. Word 97 and later for Windows; Word 98 and later for Mac OS

The newer .docx extension signifies the Office Open XML international standard for Office documents and is used by Word 2007 and later for Windows, Word 2008 and later for macOS, as well as by a growing number of applications from other vendors, including OpenOffice.org Writer, an open source word processing program.

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As with all OLE Compound Files, Word Binary Format consists of "storages", which are analogous to computer folders, and "streams", which are similar to computer files. Each storage may contain streams or other storages. Each Word Binary File must contain a stream called "WordDocument" stream and this stream must start with a File Information Block (FIB). FIB serves as the first point of reference for locating everything else, such as where the text in a Word document starts, ends, what version of Word created the document and other attributes.

Word 2007 and later continue to support the DOC file format, although it is no longer the default.

XML Document (Word 2003)

The .docx XML format introduced in Word 2003 was a simple, XML-based format called WordprocessingML.

Cross-version compatibility

Opening a Word Document file in a version of Word other than the one with which it was created can cause incorrect display of the document. The document formats of the various versions change in subtle and not so subtle ways (such as changing the font, or the handling of more complex tasks like footnotes). Formatting created in newer versions does not always survive when viewed in older versions of the program, nearly always because that capability does not exist in the previous version. Rich Text Format (RTF), an early effort to create a format for interchanging formatted text between applications, is an optional format for Word that retains most formatting and all content of the original document.

Third-party formats

Plugins permitting the Windows versions of Word to read and write formats it does not natively support, such as international standard OpenDocument format (ODF) (ISO/IEC 26300:2006), are available. Up until the release of Service Pack 2 (SP2) for Office 2007, Word did not natively support reading or writing ODF documents without a plugin, namely the SUN ODF Plugin or the Open XML/ODF Translator. With SP2 installed, ODF format 1.1 documents can be read and saved like any other supported format in addition to those already available in Word 2007. The implementation faces substantial criticism, and the ODF Alliance and others have claimed that the third-party plugins provide better support. Microsoft later declared that the ODF support has some limitations.

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Microsoft Word 2007 (Service Pack 1) supports (for output only) PDF and XPS formats, but only after manual installation of the Microsoft 'Save as PDF or XPS' add-on. On later releases, this was offered by default.

Features and flaws

Among its features, Word includes a built-in spell checker, a thesaurus, a dictionary, and utilities for manipulating and editing text. The following are some aspects of its feature set.

Templates

Several later versions of Word include the ability for users to create their own formatting templates, allowing them to define a file in which the title, heading, paragraph, and other element designs differ from the standard Word templates. Users can find how to do this under the Help section located near the top right corner (Word 2013 on Windows 8).

For example, **Normal.dot** is the master template from which all Word documents are created. It determines the margin defaults as well as the layout of the text and font defaults. Although normal.dot is already set with certain defaults, the user can change normal.dot to new defaults. This will change other documents which were created using the template, usually in unexpected ways.

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WordArt

Main article: WordArt

An example image created with WordArt

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A Macro is a rule of pattern that specifies how a certain input sequence (often a sequence of characters) should be mapped to an output sequence according to defined process. Frequently used or repetitive sequences of keystrokes and mouse movements can be automated. Like other Microsoft Office documents, Word files can include advanced macros and even embedded programs. The language was originally WordBasic, but changed to Visual Basic for Applications as of Word 97.

This extensive functionality can also be used to run and propagate viruses in documents. The tendency for people to exchange Word documents via email, USB flash drives, and floppy disks made this an especially attractive vector in 1999. A prominent example was the Melissa virus, but countless others have existed.

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Word's macro security setting, which regulates when macros may execute, can be adjusted by the user, but in the most recent versions of Word, is set to HIGH by default, generally reducing the risk from macro-based viruses, which have become uncommon.

Layout issues

Before Word 2010 (Word 14) for Windows, the program was unable to correctly handle ligatures defined in OpenType fonts. Those ligature glyphs with Unicode code points may be inserted manually, but are not recognized by Word for what they are, breaking spell checking, while custom ligatures present in the font are not accessible at all. Since Word 2010, the program now has advanced typesetting features which can be enabled: OpenType ligatures, kerning, and hyphenation. Other layout deficiencies of Word include the inability to set crop marks or thin spaces. Various third-party workaround utilities have been developed. In Word 2004 for Mac OS X, support of complex scripts was inferior even to Word 97, and Word 2004 did not support Apple Advanced Typography features like ligatures or glyph variants.

Bullets and numbering

Microsoft Word supports bullet lists and numbered lists. It also features a numbering system that helps add correct numbers to pages, chapters, headers, footnotes, and entries of tables of content; these numbers automatically change to correct ones as new items are added or existing items are deleted. Bullets and numbering can be applied directly to paragraphs and convert them to lists.[82] Word 97 through 2003, however, had problems adding correct numbers to numbered lists. In particular, a second irrelevant numbered list might have not started with number one, but instead resumed numbering after the last numbered list. Although Word 97 supported a hidden marker that said the list numbering must restart afterwards, the command to insert this marker (Restart Numbering command) was only added in Word 2003. However, if one were to cut the first item of the listed and paste it as another item (e.g. fifth), then the restart marker would have moved with it and the list would have restarted in the middle instead of at the top.

Users can also create tables in Word. Depending on the version, Word can perform simple calculations — along with support for formulas and equations as well.

AutoSummarize

Available in certain versions of Word (e.g., Word 2007), AutoSummarize highlights passages or phrases that it considers valuable and can be a quick way of generating a crude abstract or an executive summary. The amount of text to be retained can be specified by the user as a percentage of the current amount of text.

According to Ron Fein of the Word 97 team, AutoSummarize cuts wordy copy to the bone by counting words and ranking sentences. First, AutoSummarize identifies the most common words in the document (barring "a" and "the" and the like) and assigns a "score" to each word – the more frequently a word is used, the higher the score. Then, it "averages" each sentence by adding the scores of its words and dividing the sum by the number of words in the sentence – the higher the average, the higher the rank of the sentence. "It's like the ratio of wheat to chaff," explains Fein.

AutoSummarize was removed from Microsoft Word for Mac OS X 2011, although it was present in Word for Mac 2008. AutoSummarize was removed from the Office 2010 release version (14) as well.

Password protection

There are three password types that can be set in Microsoft Word:

- Password to open a document
- Password to modify a document
- Password restricting formatting and editing

The second and the third type of passwords were developed by Microsoft for convenient shared use of documents rather than for their protection. There is no encryption of documents that are protected by such passwords, and Microsoft Office protection system saves a hash sum of a password in a document's header where it can be easily accessed and removed by the specialized software. Password to open a document offers much tougher protection that had been steadily enhanced in the subsequent editions of Microsoft Office.

Word 95 and all the preceding editions had the weakest protection that utilized a conversion of a password to a 16-bit key.

Key length in Word 97 and 2000 was strengthened up to 40 bit. However, modern cracking software allows removing such a password very quickly – a persistent cracking process takes one week at most. Use of rainbow tables reduces password removal time to several seconds. Some password recovery software can not only remove a password, but also find an actual password that was used by a user to encrypt the document using brute-force attack approach. Statistically, the possibility of recovering the password depends on the password strength.

Word's 2003/XP version default protection remained the same but an option that allowed advanced users choosing a Cryptographic Service Provider was added. If a strong CSP is chosen, guaranteed document decryption becomes unavailable, and therefore a password can't be removed from the document. Nonetheless, a password can be fairly quickly picked with brute-force attack, because its speed is still high regardless of the CSP selected. Moreover, since the CSPs are not active by the default, their use is limited to advanced users only.

Word 2007 offers a significantly more secure document protection which utilizes the modern Advanced Encryption Standard (AES) that converts a password to a 128-bit key using a SHA-1 hash function 50000 times. It makes password removal impossible (as of today, no computer that can pick the key in reasonable amount of time exists), and drastically slows the brute-force attack speed down to several hundreds of passwords per second.

Word's 2010 protection algorithm was not changed apart from increasing number of SHA-1 conversions up to 100000 times, and consequently, the brute-force attack speed decreased two times more.

Reception

BYTE in 1984 criticized the documentation for Word 1.1 and 2.0 for DOS, calling it "a complete farce". It called the software "clever, put together well, and performs some extraordinary feats", but concluded that "especially when operated with the mouse, has many more limitations than benefits ... extremely frustrating to learn and operate efficiently". PC Magazine's review was very mixed, stating "I've run into weird word processors before, but this is the first time one's nearly knocked me down for the count" but acknowledging that Word's innovations were the first that caused the reviewer to consider abandoning WordStar. While the review cited an excellent WYSIWYG display, sophisticated print formatting, windows, and footnoting as merits, it criticized many small flaws, very slow performance, and "documentation apparently produced by Madame Sadie's Pain Palace". It concluded that Word was "two releases away from potential greatness".

Compute!'s Apple Applications in 1987 stated that "despite a certain awkwardness", Word 3.01 "will likely become the major Macintosh word processor" with "far too many features to list here". While criticizing the lack of true WYSIWYG, the magazine concluded that "Word is marvelous. It's like a Mozart or Edison, whose occasional gaucherie we excuse because of his great gifts".

Compute! in 1989 stated that Word 5.0's integration of text and graphics made it "a solid engine for basic desktop publishing". The magazine approved of improvements to text mode, described the $75 price for upgrading from an earlier version as "the deal of the decade", and concluded that "as a high-octane word processor, Word is definitely worth a look".

During the first quarter of 1996, Microsoft Word accounted for 80% of the worldwide word processing market.

Despite its commercial success, it has also been argued in the scientific community that Word might not be well-suited for large-scale projects with high typographical demands, due to issues such as file compatibility, poor typography, low image quality and limited feature scalability.

QUESTIONS .

1. **When was first released Microsoft Word** ?

2. When was The second release of Word for Mac OS?

3. What are Versions of the Word for Windows?

4. What do you know about Word for Mac?

5. Filename extensions how are used ?

6. What are File formats of the Word?

7. How uses Binary formats (Word 97–2007)?

8. What do you know about Templates of Word?

9. Do you know: Image formats?

10. WordArt?

11. Bullets and numbering?

12. **Software orientation?**

13. **Starting word?**

Microsoft Word (or simply Word) is a word processor developed by Microsoft. It was first released on October 25, 1983 under the name Multi-Tool Word for Xenix systems. Subsequent versions were later written for several other platforms including IBM PCs running DOS (1983), Apple Macintosh running the Classic Mac OS (1985), AT&T Unix PC (1985), Atari ST (1988), OS/2 (1989), Microsoft Windows (1989), SCO Unix (1994), and macOS (formerly OS X; 2001).

Commercial versions of Word are licensed as a standalone product or as a component **of** Microsoft Office, Windows RT or the discontinued Microsoft Works suite.

In 1981, Microsoft hired Charles Simonyi, the primary developer of Bravo, the first GUI word processor, which was developed at Xerox PARC. Simonyi started work on a word processor called Multi-Tool Word and soon hired Richard Brodie, a former Xerox intern, who became the primary software engineer.

Microsoft announced Multi-Tool Word for Xenix and MS-DOS in 1983. Its name was soon simplified to Microsoft Word. Free demonstration copies of the application were bundled with the November 1983 issue of PC World, making it the first to be distributed on-disk with a magazine. That year Microsoft demonstrated Word running on Windows.

Unlike most MS-DOS programs at the time, Microsoft Word was designed to be used with a mouse. Advertisements depicted the Microsoft Mouse, and described Word as a WYSIWYG, windowed word processor with the ability to undo and display bold, italic, and underlined text, although it could not render fonts. It was not initially popular, since its user interface was different from the leading word processor at the time, WordStar. However, Microsoft steadily improved the product, releasing versions 2.0 through 5.0 over the next six years.

In 1985, Microsoft ported Word to the classic Mac OS (known as Macintosh System Software at the time). This was made easier by Word for DOS having been designed for use with high-resolution displays and laser printers, even though none were yet available to the general public. Following the precedents of Lisa Write and MacWrite, Word for Mac OS added true WYSIWYG features. It fulfilled a need for a word processor that was more capable than MacWrite. After its release, Word for Mac OS's sales were higher than its MS-DOS counterpart for at least four years.

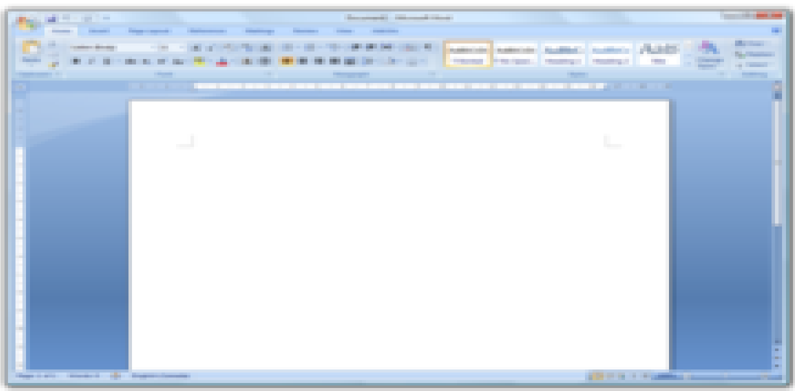
The second release of Word for Mac OS, shipped in 1987, was named Word 3.0 to synchronize its version number with Word for DOS; this was Microsoft's first attempt to synchronize version numbers across platforms. Word 3.0 included numerous internal enhancements and new features, including the first implementation of the Rich Text Format (RTF) specification, but was plagued with bugs. Within a few months, Word 3.0 was superseded by a more stable Word 3.01, which was mailed free to all registered users of 3.0. After MacWrite Pro was discontinued in the mid-1990s, Word for Mac OS never had any serious rivals. Word 5.1 for Mac OS, released in 1992, was a very popular word processor owing to its elegance, relative ease of use and feature set. Many users say it is the best version of Word for Mac OS ever created.

In 1986, an agreement between Atari and Microsoft brought Word to the Atari ST under the name Microsoft Write. The Atari ST version was a port of Word 1.05 for the Mac OS and was never updated.

The first version of Word for Windows was released in 1989. With the release of Windows 3.0 the following year, sales began to pick up and Microsoft soon became the market leader for word processors for IBM PC-compatible computers. In 1991, Microsoft capitalized on Word for Windows' increasing popularity by releasing a version of Word for DOS, version 5.5, that replaced its unique user interface with an interface similar to a Windows application. When Microsoft became aware of the Year 2000 problem, it made Microsoft Word 5.5 for DOS available for download free. As of July 2018, it is still available for download from Microsoft's web site. In 1991, Microsoft embarked on a project code-named Pyramid to completely rewrite Microsoft Word from the ground up. Both the Windows and Mac OS versions would start from the same code base. It was abandoned when it was determined that it would take the development team too long to rewrite and then catch up with all the new capabilities that could have been added at the same time without a rewrite. Instead, the next versions of Word for Windows and Mac OS, dubbed version 6.0, both started from the code base of Word for Windows 2.0.

With the release of Word 6.0 in 1993, Microsoft again attempted to synchronize the version numbers and coordinate product naming across platforms, this time across DOS, Mac OS, and Windows (this was the last version of Word for DOS). It introduced AutoCorrect, which automatically fixed certain typing errors, and AutoFormat, which could reformat many parts of a document at once. While the Windows version received favorable reviews (e.g., from InfoWorld), the Mac OS version was widely derided. Many accused it of being slow, clumsy and memory intensive, and its user interface differed significantly from Word 5.1. In response to user requests, Microsoft offered Word 5 again, after it had been discontinued. Subsequent versions of Word for mac OS are no longer direct ports of Word for Windows, instead featuring a mixture of ported code and native code.

Word for Windows



Microsoft Word 2007

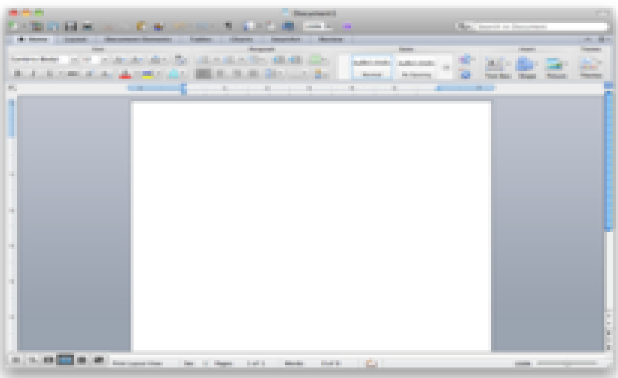
Word for Windows is available stand-alone or as part of the Microsoft Office suite. Word contains rudimentary desktop publishing capabilities and is the most widely used word processing program on the market. Word files are commonly used as the format for sending text documents via e-mail because almost every user with a computer can read a Word document by using the Word application, a Word viewer or a word processor that imports the Word format (see Microsoft Word Viewer).

Word 6 for Windows NT was the first 32-bit version of the product, released with Microsoft Office for Windows NT around the same time as Windows 95. It was a straightforward port of Word 6.0. Starting with Word 95, releases of Word were named after the year of its release, instead of its version number.

Word 2010 allows more customization of the Ribbon, adds a Backstage view for file management, has improved document navigation, allows creation and embedding of screenshots, and integrates with Word Web App.

Word for Mac

The Mac was introduced January 24, 1984, and Microsoft introduced Word 1.0 for Mac a year later, on January 18, 1985. The DOS, Mac, and Windows versions are quite different from each other. Only the Mac version was WYSIWYG and used a graphical user interface, far ahead of the other platforms. Each platform restarted its version numbering at "1.0" (https://winworldpc.com/product/microsoft-word/1x-mac). There was no version 2 on the Mac, but version 3 came out on January 31, 1987, as described above. Word 4.0 came out on November 6, 1990, and added automatic linking with Excel, the ability to flow text around graphics and a WYSIWYG page view editing mode. Word 5.1 for Mac, released in 1992 ran on the original 68000 CPU and was the last to be specifically designed as a Macintosh application. The later Word 6 was a Windows port and poorly received. Word 5.1 continued to run well until the very last Classic Mac OS. Many people continue to run Word 5.1 to this day under an emulated Mac classic system for some of its excellent features like document generation and renumbering or to access their old files.



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Layout issues

Before Word 2010 (Word 14) for Windows, the program was unable to correctly handle ligatures defined in OpenType fonts. Those ligature glyphs with Unicode code points may be inserted manually, but are not recognized by Word for what they are, breaking spell checking, while custom ligatures present in the font are not accessible at all.

Since Word 2010, the program now has advanced typesetting features which can be enabled: OpenType ligatures, kerning, and hyphenation.

Other layout deficiencies of Word include the inability to set crop marks or thin spaces.

Various third-party workaround utilities have been developed.

In Word 2004 for Mac OS X, support of complex scripts was inferior even to Word 97, and Word 2004 did not support Apple Advanced Typography features like ligatures or glyph variants.

Bullets and numbering

Microsoft Word supports bullet lists and numbered lists. It also features a numbering system that helps add correct numbers to pages, chapters, headers, footnotes, and entries of tables of content; these numbers automatically change to correct ones as new items are added or existing items are deleted.

Bullets and numbering can be applied directly to paragraphs and convert them to lists. Word 97 through 2003, however, had problems adding correct numbers to numbered lists. In particular, a second irrelevant numbered list might have not started with number one but instead resumed numbering after the last numbered list.

Although Word 97 supported a hidden marker that said the list numbering must restart afterward, the command to insert this marker (Restart Numbering command) was only added in Word 2003.

However, if one were to cut the first item of the listed and paste it as another item (e.g. fifth), then the restart marker would have moved with it and the list would have restarted in the middle instead of at the top.

Users can also create tables in Word. Depending on the version, Word can perform simple calculations — along with support for formulas and equations as well.

SOFTWARE ORIENTATION

Microsoft Word's Primary User Interface Before you begin working in Microsoft Word 2016, you need to acquaint yourself with the primary user interface (UI).

When you open a blank document in Microsoft Word 2016, you see a screen similar to that shown in Figure 1.

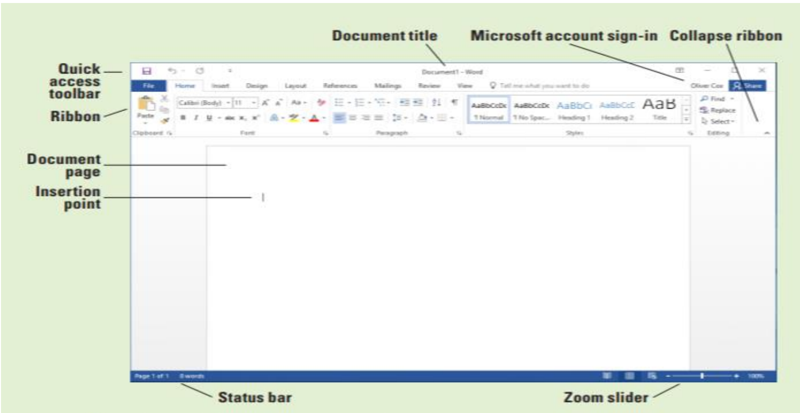


Figure 1.

Quick access

toolbar Ribbon

Document title

Microsoft account

sign-in

Collapse ribbon

Status bar

Zoom slider

Document page

Insertion point

Microsoft has designed the Word UI to provide easy access to the commands you need most often when creating and editing documents. (Note that your screen might vary somewhat from the one shown here, depending on your program's settings.)

STARTING WORD

2016 Microsoft Word is a word processing tool for creating different types of documents that are used in work and school environments.

The appearance of Microsoft Word 2016 is similar to Word 2010 and Word 2013, but with more enhanced features.

It contains a customized Office Background that appears above the Ribbon, live access to your OneDrive account, an option to work in Read Mode, tab text that appears blue when active, a blue background for the status bar, and many more exciting new features.

When you first launch Word, it opens with the Recent screen displayed.

This screen enables you to create a new blank document or a document from a template.

And when you exit a document and return later, Word 2016 resumes where you left off.

Starting Word

In this exercise, you learn how to start Word using Windows 10. In Windows 10, clicking the Start button displays the Start menu (see Figure 1-2).

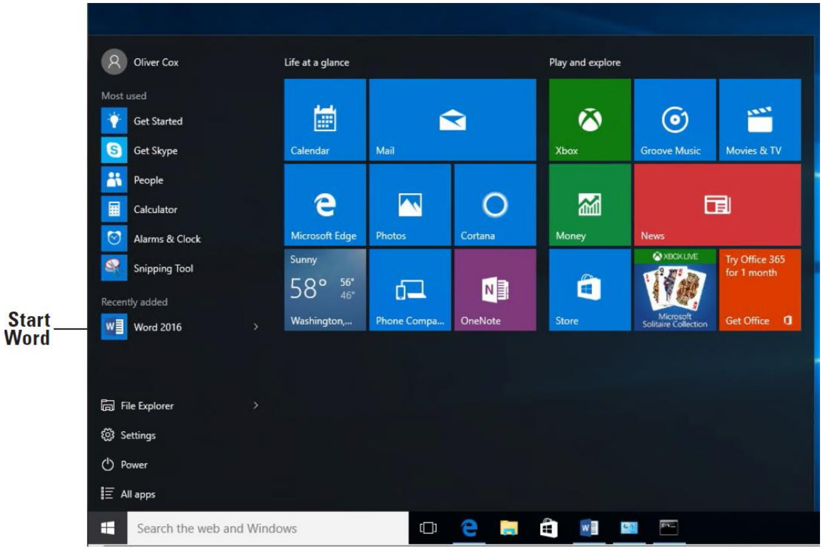


Figure 1-2

On this menu, you can choose which application to launch by using your mouse or, if you have a touch-screen monitor, by tapping the application you want to launch. The Start menu provides access to mail, OneDrive, Microsoft Edge, photos, games, music, video, and of course the latest version of the Microsoft Office applications.

On tablets with Windows Mobile and the Office 2016 applications installed, you can customize the interface the same way as your Start menu. If you don't have Office 2016 installed on your computing device, you can still create, view, and perform simple edits on Word documents using an online Word Web App. Office Web Apps are available for Word, Excel, PowerPoint, and OneNote. You launch Office Web Apps using a web browser, such as Microsoft Edge. One of the differences between the Word Web App and the Word 2016 application installed on your computer is the number of features available.

The Word Web App enables you to create, open, and edit documents with only the most basic commands. It is a wonderful way to create a simple document and share it. The main advantage of using the Word 2016 application installed on your computer is having full access to all the features needed to create a professional-looking document. If you use the Word Web App, you will not be able to complete all of the exercises in this book, because it does not include all of the Word features. Microsoft has a cloud-based storage space known as OneDrive. Microsoft provides users with free online storage space, enabling you to manage your documents from anywhere and share them with anyone.

Before you can use OneDrive, however, you must create a Microsoft account profile. Once you create your account, you will find it easy to manage and share your documents. Windows 10 works seamlessly with Office 2016. When you are logged on to your Microsoft account, the account name appears in the upper-right corner of each Office 2016 application and you have access to the files you have stored in your OneDrive space. This makes it easy for you to continue working on your documents at any computer and reminds you where you left off. To begin using Word 2016, locate the Word icon and click it using the left mouse button or, if you are using a touch-screen monitor, tap the icon.

When Word is launched, the program opens with the Word 2016 screen. On the left side of the screen under Recent, you see a list of documents that have been accessed recently. The right window pane displays a blank document page and several templates to create customized documents. To create a blank document, click the Blank document page and Word will open a new document.

The blinking insertion point in the upper-left corner of this document is where you begin creating your text. When you place your cursor near it, the insertion point changes to a large “I,” which is called the I-beam.

Take Note

The lessons in this book are created using the Windows 10 operating system. If your computer is running the Windows 8.1 or

Windows 7 operating system, some screenshots and steps might appear slightly different than those provided in this book.

STEP BY STEP

Start Word GET READY.

Before you begin these steps, be sure to turn on and/or log on to your computer.

1. On the Windows 10 desktop, click the Start button. The Start menu appears (see Figure 2).

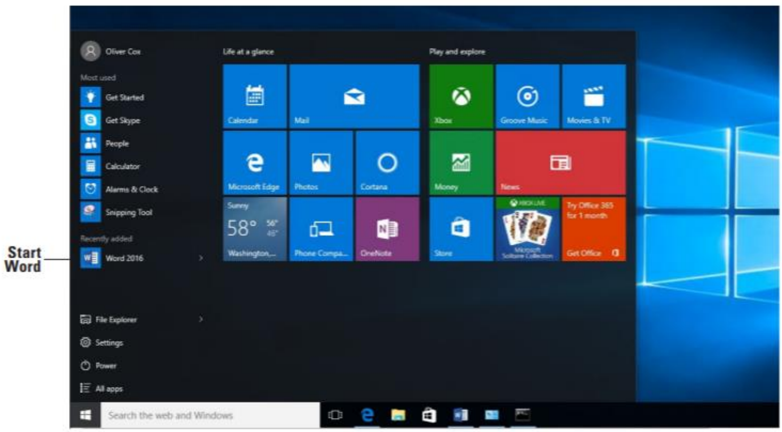


Figure 2.

2. On the Start menu, locate Word 2016 and click the icon. The Word 2016 screen appears (see Figure 1-3). On the left side of the screen, you see the recent documents that have been accessed, and the right side displays the blank document page and templates.

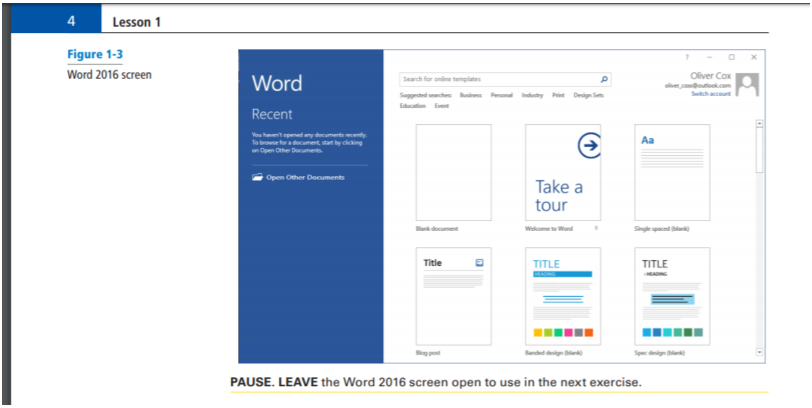


Figure 3.

GET READY.

Start with the File > New screen open.

1.Click the Blank document icon to create a new document file. The Ribbon is located at the top of the Word screen. In your newly opened document, the Home tab is the default tab on the Ribbon, as shown in Figure 4. Note how the Ribbon is divided into groups: Clipboard, Font, Paragraph, Styles, and Editing.

Figure 4.

2. Review the other tabs on the Ribbon and review each group associated with the tab, and identify the arrows that launch a dialog box (if present).

3. Click the Layout tab to make it the active tab. Notice that the groups of commands change. The Layout tab contains three groups: Page Setup, Paragraph, and Arrange. Notice that in the Page Setup and Paragraph group a small arrow appears in the lowerright corner. Clicking on the arrow opens the dialog box with more options to select or complete a command.

4. Click the Home tab.

5. Click the dialog box launcher in the lower-right corner of the Font group. The Font dialog box, as shown in Figure 5, appears. The Font dialog box contains two tabs with the Font tab being the active tab. There are many options to select within the Font dialog box. You can click Cancel if you want to close the dialog box. We'll continue without clicking Cancel.

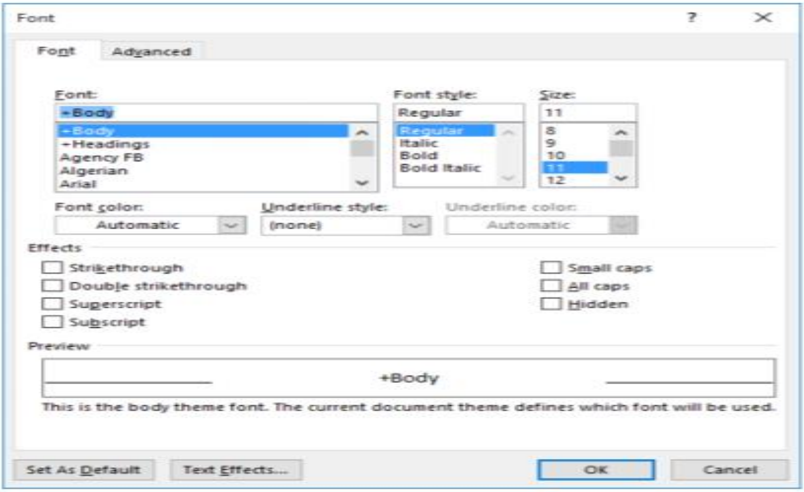


Figure 5.

6. Click the drop-down arrow on the Font command box in the Font group to produce a menu of available fonts, as shown in Figure 6.

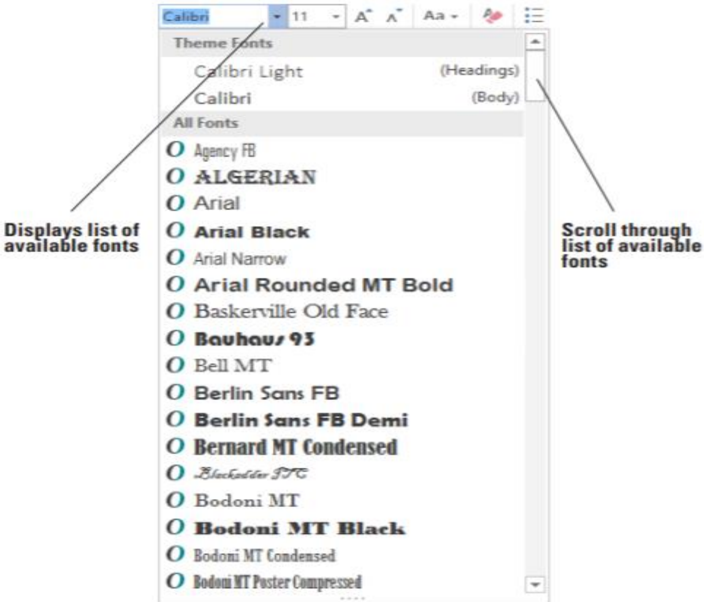


Figure 6.

7. Click the arrow again to close the menu.

8. Double-click the Home tab. Notice that the command groups are now hidden, to give you more screen space to work on your document.

9. Double-click Home again to redisplay the groups.

USE the document that is open from the previous exercise.

1. The insertion point should be positioned at the top of the page.

2. Type the month, day, and year of today's date. Press Enter twice.

3. Type the delivery address as shown: Ms. Miriam Lockhart (Press Enter once.)

4. Type Dear Ms. Lockhart:

5. Press Enter once.

6. Type the following text and press Enter once after each paragraph.

7. Press Enter once.

8. Type Sincerely

9. Press Enter twice

10. Type Steve Buckley.

When saving a document for the first time, you must specify a filename, the file type, and a place where you can access the document. The filename should help users find and identify the file, and the file location should be convenient for the file's future users.

You can save files to portable storage devices such as a flash drive, to your computer's hard drive, to a network location, or to OneDrive. The Save As command enables users to save their work to the cloud and access the document quickly from any computer or tablet.

USE the document that is open from the previous exercise.

1. If necessary, connect your flash drive to one of the USB ports on your computer.

2. Click the File tab, and then click the Save As command. The Save As screen appears. There are three options available to save your document: OneDrive, This PC, and + Add a Place. Click This PC.

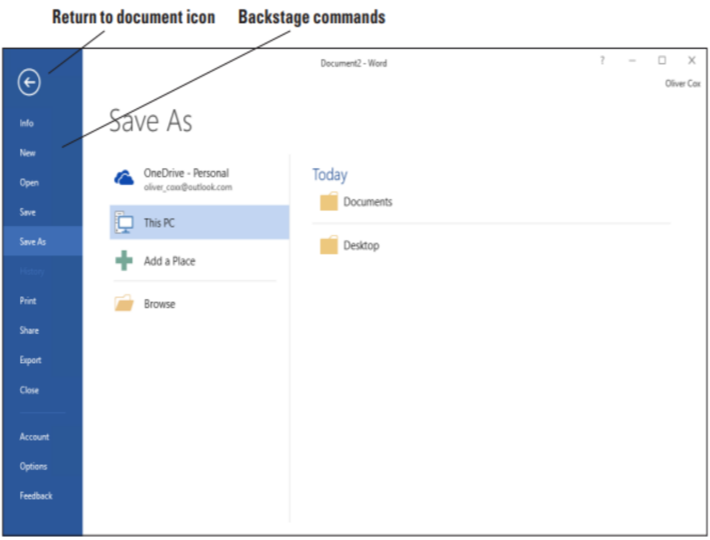


Figure 7.

3. Click Browse. The Save As combo box appears. In the Windows 10 environment, the Documents Library is the default location for saving new files. Change the location from the default to your flash drive by using the vertical scroll bar and scrolling down until you see This PC. Expand the This PC container and select your flash drive. Storage devices are given a specific letter identified by the operating system. For example, your flash drive might be labeled as Removable Drive (I:).

4. Click the flash drive to select that as the location to save your document.

5. By default, the first few characters that you typed in your document appear in the File name box. Drag the mouse over the text and press Delete or begin typing over the highlighted text. Then, type Tech Terrace Letter in the File name box and click Save.
6. If a prompt appears to upgrade to the newest format click the OK button. This action allows you to use the new features in Word 2016.

Use Print Preview

OPEN the Welcome Memo document that you created earlier.

1. Click the File tab, and then click Print. The Print screen opens with the Print options on the left and the Print Preview on the right, as shown in Figure 8.

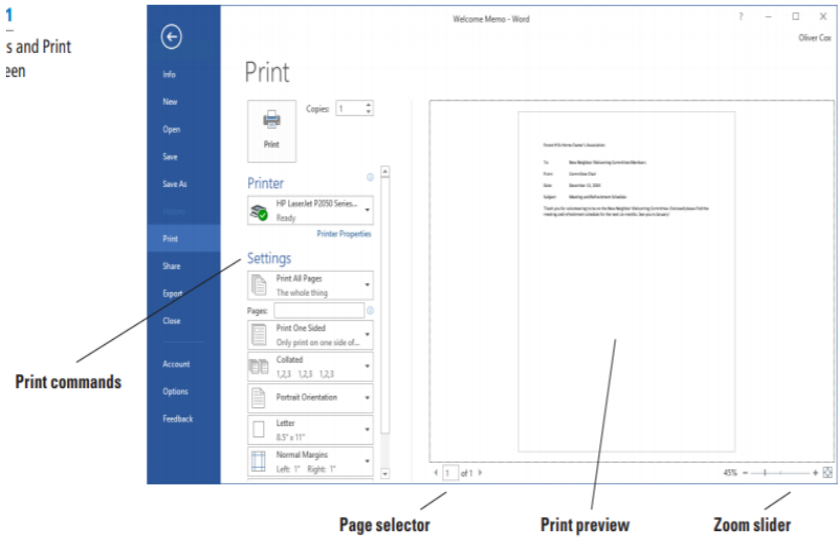


Figure 8.

2. Click the plus symbol (+) on the Zoom slider located on the bottom-right of your screen until the zoom level changes to 100%.

3. Click the Return to Document icon or press the Esc key to close Backstage.

4. Click the File tab, and then click SAVE. Your document will be saved with the same filename on your flash drive.

Choose a Printer

USE the document that is open from the previous exercise.

1. Click the File tab, and then click Print.

2. In the Printer selection area, click the drop-down arrow to produce a list of all printers connected to your computer (see Figure 9).

Figure 9

3. Select a printer, and then click the Print icon.

Set Print Options

USE the document that is open from the previous exercise.

1. Click the File tab, and then click Print. Click the drop-down arrow on Print All Pages to produce the menu shown in Figure 10.

2. Select Print Current Page, and then click the Print icon. Selecting this option prints the current page.

3. Return to the Print screen area. In the Copies section of the Print options area, click the up arrow to select 2, and then click the Print icon.

4. Place your insertion point at the beginning of the first paragraph, and then hold down the left mouse button and drag to the end of the paragraph to select it.

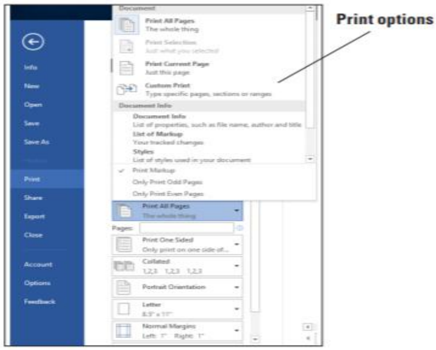
5. Click the File tab, and then click Print. Click the Print Current Page drop-down arrow, select Print Selection, and then change the number of copies from 2 to 1 by clicking the down arrow. Next, click the Print icon. The selected paragraph is printed.

6. Click the File tab, and then click Close to close the document.

7. The Annual Report document should still be open from a previous exercise.

Click the File tab, and then click Print. Under Settings, click the drop-down arrow by 1 Page Per Sheet and select 2 Pages Per Sheet, and then click the Print icon. This eight-page document is now printed on four pages with two pages per sheet.

8. Click the Close button to close both the document and Microsoft Word.



Select the best response for the following statements.

1. The first screen you see when you open Word 2016 is called the:

a. Word screen

b. Recent screen

c. Start screen

d. Screen saver

2. Which of the following contains the commands you use most often, such as Save, Undo, and Repeat.

a. Quick Access Screen

b. Quick toolbar

c. Quick Access Toolbar

d. Quick command

3. The headings that appear on the Ribbon, such as File, Home, and Insert, are called:

a. groups

b. tabs

c. shortcuts

d. menus

4. Which command would you use to save a document for the first time?

a. Save

b. Save As

c. Save for th e first time

d. Either a or b

5. Which of the following options would you use when saving a document with a new filename?

a. Save

b. Save As

c. Ctrl+S

d. Either a or b

True/False Circle “T” if the statement is true or “F” if the statement is false.

T F 1. When you start Word 2016, a new blank document appears.

T F 2. Clicking the Print button on the Backstage Print screen sends the document straight to the currently selected printer with the default settings.

T F 3. The File tab can be used to save and print files.

T F 4. You can hide the Ribbon by double-clicking the active tab.

T F 5. Previewing and printing can be completed by accessing Backstage

GLOSSARY

Arrow-(n)- ox Arrowhead
ox işarəsi
On the bottom-aşağıda
Bottom-aşağı
Top- yuxarı
Spell- check text- mətnin
orfoqrafik yoxlanması
As eaasily as- asnalıqla
Underline- sətiraltı xətt
Bold- yağlı
Reflection- əks
Glow- parıltı
Bevel- maili (adj)
Three dimensional effects-
3 ölşülü effektlər
Stretching- dartılma
Rotating- fırlanma
Skewing-assimetrik
Shadoüing- kölgələndirmə
Watermark-sulu işarə
Graphical effects- qrafik
effektlər

Hierarchical(
hayərarxikal)- iyerarxik adj
Compound file- mürəkkəb
fayl
Capability- imkan
Binary (baynəri)
document- ikili sənəd
Embedding of screenshot-
ekran görüntüsünün
yerləşdirilməsi
Improve-
yaxşılaşdırmaq(v)
Backstage-off stage- arxa
planda
Is widely used- widely
used- geniş istifadə olunur
Publishing capabilities-
nəşr imkanları
Aware-adj-informed-
məlumatlandırılan
Compatible- uzlaşan-
consistent- adj

Pick up- yuxarı qaldırmaq
Rival- competetiv – rəqiblik adj
Across- arasında
Attempt- cəhd etmək- try
Storage- saxlanc yeri
Tap- basmaq
Shipped- yüklənməsi
Launch- yükləmək
Zoom- slider- maştab kiçildən
Sign in- sistemə giriş
Insertion point- kursor
Ribbon- lent
Tool bar –alətlər paneli
Title- başlıq(taytl)
Acquaint (əkvant)V-tanış etmək –introduce
Resume- xülasə
Item (aytem)-məqalə- article

Footnotes- istinadlar
Chapter- fəsil
Page- səhifə
Headers- başlıqlar
Bullet-(bolit)-nüvə- core
Entries- yazılar
Subscriber- abonent
Display- göstərmək
Font- şrift
Margin- sahə
Template- şablon
Filename extension- fayl adının genişlənməsi
Legacy- miras- heritage
Slightly- bit- bir az
Standalone- avtonom
Release- buraxılmaq
Newer-yeni
Signifi-məna daşımaq(mean, indicate)

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METHODS AND PRİNCİPLES OF USİNG ELECTRONİC AND MULTİMEDİA TEACHİNG TOOLS

Many teaching tools are being developed to make learning in subjects such as Islamic studies, language, science and technology less abstract and theoretical, thus making it easier to learn and capture the students' interest. Visualization and interaction techniques are being applied in several e-learning projects in our classrooms. Three e-learning projects which are 'Greenfoot as a Teaching Tool in Programming', 'Visualization makes Array Easy (VAE)' and 'e-Tajweed

Yassin' applications strive to engage the students by allowing them to visualize the concept learned, its behaviour and operation using animation, games, simulation and other elements, in contrast to more conventional teaching method. Hence, the students can obtain a new learning experience with better understanding of the concepts and perform better in their assessments. The outcomes from these studies have shown positive results from the students. This paper compares between the three applications: Greenfoot, VAE and e-Tajweed where it discusses the design models used that meet the instructional goals and objectives, and how nontechnical students respond to the information presented. Index Terms—Innovative Teaching; Multimedia; Teaching Tools; Visualization.

INTRODUCTION

A multimedia application is a creative presentation of a combination of media such as sound, graphic, text and animation. The development of such applications supports education system by improving knowledge sharing process and at the same time influence people to think creatively. There are many multimedia applications in the market that serve for educational purposes that can be used freely or with some fees. Each application has certain area or subject taught which is following a certain syllabus and the syllabus may vary for different courses. Currently, department of computer science in UiTM Negeri Sembilan has developed three multimedia applications which are Greenfoot, Visualization makes Array Easy (VAE) and e-Tajweed for education purpose. Different approaches are used to develop the application; nevertheless, the feedbacks from users are reasonably good. The objective of this paper is to compare the development process of the three applications in terms of constructivist approach; integration of formal and informal activities; integration of social learning and the delivery hours needed for the teaching and learning process in order to identify the best approach that can be used to develop multimedia application for educational purposes. This paper presents the idea by using the following scheme: a) Literature review, b) Justification of three multimedia applications, c) Methodology used, d) Result and discussion and e) Conclusion.

EXISTING TEACHING TOOL

An e-learning system can support learning with the aid of multimedia components such as text, audio, video and animation. There are a number of studies that have identified multimedia components to assist learning for students. Past research has identified that complication of the multimedia component has enabled students to use their mental skills in a more effective way. At the same time, multimedia and interactive components also support self-learning. Many teaching tools are being developed to make learning in subjects such as Islamic studies, language, science and technology to be less abstract and theoretical.

A study has demonstrated educational technology such as PowerPoint presentation has played a positive role in Islamic studies. The success of the Computer Application of Electromagnetic Education (CAEME) is another proof of effectiveness with the use of multimedia in education . CAEME uses innovative multimedia modules which have been supported by the IEEE society. With the implementation of multimedia as a tool for learning, it has captured the students' interest and made them passionate in the learning process . It can be concluded that multimedia components such as animation and videos to be a powerful tool to communicate facts, explain concepts and trigger emotions. The following section will discuss the three applications; Greenfoot, VAE and Tajweed Yassin in details. A. Greenfoot as a Teaching Tool in Object Oriented Programming Greenfoot is a tool that allows the creation of scenario to ease visualization of 2D objects interaction in teaching object-oriented programming.

A scenario is a term used in Greenfoot to indicate a project. The scenario has been created by using Greenfoot environment and has been used as a teaching tool for Introduction to Object-Oriented Programming course. The scenario created in Greenfoot demonstrates the visualization and object interaction elements, engage student's interest in learning; provide a clear illustration of object-oriented concepts and easy development of a game-like application from the scenario provided. One of the sub-topics covered in the scenario is how a method is invoked in Java. Figure 1 depicts the Greenfoot's screen that shows the method invocation with a return parameter. The scenario in Greenfoot has been tested to 20 students to assess the usability of the teaching tool. System Development Life Cycle (SDLC) has been applied as a methodology. Students found that learning object-oriented using the teaching tool which is created using Greenfoot environment Journal of Telecommunication, is easy-to-use and simple to learn. Hence, the students responded that they are able to visualize object quickly by using this teaching tool. B. VAE VAE is developed based on the ADDIE model (Analysis, Design, Develop, Implement and Evaluate) which is a model of instructional design. In the analysis, visualization techniques are identified as one of the main factors that cause students to easily understand the concepts of programming. VAE design process takes about one week in order to create a storyboard. The storyboard is used as a guide to develop VAE. In the development process, the two main softwares that have been used to develop VAE are Video Scribe and MS PowerPoint with i-Spring. VAE is beneficial to the students and lecturers in teaching and learning the introduction to programming. Array is the main focus in VAE since the lecturers had found that it was hard for the students to understand. A simple test is carried out by 60 students and the results showed that VAE with simulation technique is effective in helping the students to learn the concepts of programming. Features such as learnability, efficiency, memorability, accuracy and satisfaction are contributing factors in determining the effectiveness of the prototype VAE. VAE helps the students to understand the concepts of programming. There is a significant increase in the student test results and therefore can be concluded that the VAE has helped them in getting a better understanding and further showed better results .

The technique of visualization and interactive was identified to support studying and understanding of tajweed during the analysis stage. In the design stage, the layout of contents was designed to be easily accessible by the users. The graphical user interface (GUI) was to imitate the traditional method known as syafawiah. The system emphasizes on the common mistakes that usually done by the previous students who have undergone the course.

Finally, the actual recitations of the verse are presented by a video of an authentic reciter for each of the verses in the Surah of Yassin. The combination of audio, video and animation was more effective than text mode of promoting learning . A number of 51 students were selected to use the system and later, they were being evaluated based on their ability to read the surah of Yaasin. Data collected was based on student's ability to recite the verses of twenty until forty of the surah of Yassin after the implementation of this interactive system. The result of these students was then compared to the previous semester students who did not use the system. It was found the e-Tajweed Yassin system was able to improve the reading of students where the numbers of mistakes have been reduced to all the rules. The system is beneficial to the student and instructors since it reduced the instructional time and allowed self-study for students.

METHODOLOGY

This experimental study is intended to look at the effectiveness of teaching and learning approaches/strategies in three different multimedia education tools developed: Greenfoot, VAE and E-Tajweed in order to improve the content and delivery. In comparing the identified multimedia education tools, four elements are being used.

A. Constructivist Approach Constructivism is a learning theory where students are able to construct knowledge based on their experiences. It is used with pedagogical approaches that promote active learning. Past researcher mentioned in his research that to be successful, a teaching method motivated by constructivism needs to be organized around a set of activities.

B. Integration of Formal and Informal Activities The use of audiovisual media added with video, animation and simulation can effectively improve the context of the learning process and academic assessments results .

C. Integration of Social Learning The Social Learning Theory focuses on the participation process of individual learner to develop their skills and abilities. Generally, social learning is the understanding which is built through interaction with the learning elements in the application.

D. Delivery Hours The delivery hours slotted per topic are usually set in the course syllabus. The time that the teacher spends for the delivery to make the learner understand are varied according to the learner's cognitive capability but still within the allocated time.

RESULTS AND DISCUSSION

Three elements that are evaluated in these three applications are constructivist approach; integration of formal and informal activities and integration of social learning. Even though all three identified elements are not found in all the three multimedia applications (Greenfoot, VAE, eTajweed), but they managed to meet the objectives of making the students to be able to understand their topics better and incite their interests. The considerable point of this study is the effect of these three multimedia education tools on teaching and learning process in term of hours spent. Multimedia education tools could promote the ease of use and provide better guideline with the help of sounds effect, video, animation and more effective than traditional face-to-face lecture method.

For example, the lecturer took 8 hours to deliver and discuss the topic with the students in the class. In contrast, by using VAE, the allocation of time can be reduced by 2 hours. The reason for this difference lies in the nature of multimedia itself. Since multimedia education tools can help the student to interpret and visualize about ideas and concepts, it will allow the students to engage and increase their motivation and understanding for their learning. Therefore, in multimedia education tools, the students can learn by themselves, save time spent for teaching and this will promote self-learning as well.

CONCLUSION AND FUTURE WORKS

In this study, four elements have been used to compare between three multimedia education tools. The first three elements include constructivist approach, integration of formal and informal activities and the integration of social learning. The existences of all three elements were shown in Greenfoot application, but not in VAE and e-Tajweed. Both constructivist approach and integration of formal and informal activities do not show in eTajweed; however, the latter is shown in VAE. Although the three elements did not show in all the applications, experimental results indicate that these multimedia tools can reduce the delivery hours if compare to the traditional lecture face-to-face. In conclusion, multimedia education tools can promote effective teaching and learning in general. In future works, a multimedia education tool will be developed based on the three elements mentioned and integrate it with game-based learning, quizzes and usability test will be conducted in order to add a variety of elements offered in a tool, thus promoting a better multimedia education tool. ACKNOWLEDGMENT This study is supported by UiTM Negeri Sembilan training grants.

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NEW DIRECTIONS OF ICT-USE IN EDUCATION

Ministry of Education took some steps in order to use the ICT in the education process. Thus, until 2004 the information science subject was taught in the 9-11th grades. However, according to the teaching plan for the 2004-2005 school year this subject began to be taught from the 1st grade, additionally, was approved the new programme for the 1-11th grades as well. The information science textbooks for the I-VIII grades are already in use, for other grades it is in preparation phase.

In 2006, 218 schools of Baku and Sumgait connected to the Internet within the memorandum of agreement signed between the Ministry of Education and CISCO SYSTEMS (USA). Since 2002, the Ministry with the co-operation of Project Harmony Organization has implemented measures to establish the Internet centres and use of computer technologies in learning process within the Relations and Exchange Program.

Currently, the project encompasses a vast majority of schools. Resource centres opened at these schools were supplied with relevant equipments and were implemented training of teachers.

Memorandum of understanding on cooperation in the development of modern information technologies in the area of education between the Ministry of Education and “Microsoft” defines collaboration frames and conditions for the development of Education Partnership Initiative. In order to achieve the purposes of memorandum were implemented cooperation measures on 10 projects until December of 2007.

The Ministry of Education utilizes the practice of ICT use of developed countries in the education system. In June 2006 the delegation of the Ministry of Education took part in the international seminar on the theme of “Innovation in the electronic training area”, organized by the financial support of “Hewlett Packard” (HP), and held in Belfast, Great Britain.

Intel Company implements programs towards to the efficient use of ICT in the education system for years. “Education for future” is one of the seven innovation programs implemented by the “Intel” in the world. The goal of the program is to improve the professional skills of teachers of technical specialized schools and pedagogical universities. The program is being successfully implemented in the 37 countries of the world. Azerbaijan is the third country after Russia and Ukraine that joint to this program.

The Ministry of Education took some steps in the direction of ICT use in the education process as well. Thus, until 2004 the information science subject was taught in the 10-11th grades. However, according to the teaching plan for the 2004-2005 school year this subject began to be taught from the 1st grade, additionally, was approved the new programme for the 1-11th grades as well. The information science textbooks for the I-VIII grades are already in use, for other grades it is in preparation phase.

The ICT is being applied widely at universities as well. Currently, teachers and engineers are prepared on the information science specialty at higher and secondary professional schools such as - Baku State University, ASOA, ASUA, AMU and others, as well as Baku Computer College.

The ICT, except the secondary education system, is being applied widely at universities as well. Currently, at higher and secondary professional schools such as - Baku State University, ASOA, ASUA, AMU and others, as well as Baku Computer

College is prepared teachers and engineers on the information science specialty.

After Azerbaijan has gained its independence legislation base on ICT has been improved. Moreover, important documents were passed by the relevant orders and decrees of the President:

1. National Information and Communication Technologies Strategy for the Development of the Republic of Azerbaijan (2003-2012)

2. The Law of Azerbaijan Republic on the digital electronic signature

3. The Law of Azerbaijan Republic on electronic document

4. The Law of Azerbaijan Republic on obtaining of information

5. The Law of Azerbaijan Republic on telecommunication

6. The Law of Azerbaijan Republic on approval of classification, organization and provision of conditions (demands) of the universal telecommunication services

7. The Law of Azerbaijan Republic on Mass Media

8. The Law of Azerbaijan Republic on information, informatization and protection of information

10. The Law of Azerbaijan Republic on obtaining of environmental information

11. State Program on the development of communication and information technologies in the Republic of Azerbaijan for the years 2005-2008

12. State Program on the provision of comprehensive schools of the Republic of Azerbaijan with ICT (2005-2007)

School teachers were involved in the training courses held at Baku Science and Teaching Centre to improve their ICT abilities. They took the exam within ECDL programme and received the international certificate. Another group of teachers took part at training courses organized by the Intel Company and received "Teacher of the teachers" certificate. In general, more than 13 000 teachers jointed to these courses during 2005/2007

INTRODUCTION

Information and communications technologies (ICT) are a diverse set of technological tools and resources used to communicate, and to create, disseminate, store, and manage information. Communication and information are at the very heart of the educational process, consequently ICT-use in education has a long history. ICT has played an educational role in formal and non-formal settings, in programs provided by governmental agencies, public and private educational institutions, for-profit corporations and non-profit groups, and secular and religious communities. Much has been written about the use of film, radio, telephones, and television in education,

Because access to digital tools, applications, and networks continues to grow worldwide and media are increasingly available in digital form, ICT-use in education can be expected to increase dramatically. Our Focus As noted in the World Education Report (UNESCO, 1998a), education worldwide is facing a significant challenge in preparing students and teachers for “our future ‘knowledge-based’ society” during a time when most teachers are not prepared to use ICT and “the majority of existing school buildings, even in the most developed countries, are not equipped to integrate the new information and communication technologies.” We focus on “new” digital ICTs with special emphasis on educational uses of the Internet and the World Wide Web. In our discussion, we will consider several important issues in respect to the use of ICTs in educational settings including how newer ICTs differ from older technologies, why these differences are thought to be educationally important, what research shows about the effectiveness of ICTs in education, what measures are being taken to create ICT-enabled learning environments, and some of the significant issues facing educators and policy-makers when considering implementing ICT.

Although our focus will be on formal education, we will also refer to the use of ICT in non-formal and informal education. Along the way, we will provide a few of the innumerable possible examples of current educational ICT applications. We hope to illuminate trends that will help readers to understand current directions and promising practices in the application of these systems in educational settings. However, although digital ICTs are quickly becoming more accessible, it is important to note that earlier ICTs continue to play a critical role in education worldwide.

Access to films, videotapes, telephones, television or radio is still far more commonplace than access to a computer or the Internet and World Wide Web. For example, the Telesecundaria Project 2 in Mexico, which began in 1965 as a closed-circuit pilot project, today delivers classes designed for lower secondary school level to over 12,000 rural communities enrolling more than 800,000 students. The Mexican government plans to open an additional 4,500 Telesecundaria schools enrolling 250,000 more students between 1998 and 2002 (Calderoni, 1998). The Gobi Women's Project is using radio to deliver instruction including livestock rearing techniques, family care, income generation, and basic business skills to 15,000 nomadic women in Mongolia (UNESCO/UNICEF, 1997a). And, according to a World Bank Report, the China TV University system enrolls over half a million students in degree programs and graduates over 100,000 per year (Potashnik & Capper, 1998). The new digital ICTs are not single technologies but combinations of hardware, software, media, and delivery systems.

Today, ICT in education encompasses a great range of rapidly evolving technologies such as desktop, notebook, and handheld computers; digital cameras; local area networking; the Internet and the World Wide Web; CD-ROMs and DVDs; and applications such as word processors, spreadsheets, tutorials, simulations, electronic mail (email), digital libraries, computer-mediated conferencing, videoconferencing, and virtual reality. It should also be noted that use of newer ICTs is being integrated with use of older technologies. For example, it is not uncommon to find textbooks sold with CD-ROMs containing multimedia materials or links to related websites (cf. http://www.mmhschool. com/teach/socialstud/socstu1.html).

An exhaustive review of all of these technologies, combinations of technologies, and applications is not possible here. We also acknowledge the difficulties in implementing such innovations, and we are sensitive to the fact that whatever is said now about ICTs in education will quickly become outdated as the technologies and educational applications continue to rapidly evolve. Changes in Communications and Information Industries Our emphasis on digital ICT tools and applications in education mirrors profound structural changes occurring worldwide in communications and information industries.

The ability to digitize analog signals and transmit them over telecommunications networks is resulting in the restructuring of the radio, telephone, television, publishing, entertainment, and computer industries into new multimedia industries that create digital products combining voice, video, text, graphics, images, and animations, and deliver these signals electronically (Bane, Bradley, & Collins, 1995). An example of this trend can be found in Hong Kong where New World Telephone is installing “PowerPhones” from which users may read or send electronic mail, send a fax, search online multimedia directories about hotels and tourist spots, and make a telephone call (South China Morning Post, 1998).

Another example is Internet “telephony” software that now makes it possible to place domestic and international calls from a computer to a 3 current estimate places the total number at around 150 million in late 1998, an increase of over 60% since early 1997 (Nua Internet Surveys, 1998).

Internet access is at present strongly concentrated in a small number of countries, providing services to a fraction of the world's population: over 90% of Internet hosts are located in the world's richest 29 counties (Cukier, 1998). However, this may be expected to change over time as telecommunications costs continue to drop precipitously and governments deregulate access. For example, the number of Internet users in India is expected to climb from half a million in 1998 to 1.5 million by the year 2000 (Rao, 1998). In Africa, it is estimated that there currently are between 800,000 and 1 million Internet users. The current ratio of Internet users to people in Africa is estimated to be one for every 5,000 compared to a world average of about one Internet user to every 40 people. But here, too, the situation is rapidly changing.

In 1996, only 16 countries in Africa had Internet access. Now, 53 (three-fourths) of the capital cities are online and the rest will soon follow. A number of international infrastructure building initiatives are underway on the continent including the United Nations Secretary General’s programme Harnessing Information Technology for Development that will substantially improve the Internet infrastructure by the year 2000 (Jensen, 1998a). The Russian Non-Profit Center for Internet Technologies estimates that there are now about 1 million Russians online and that this number is doubling every year (http://www.rocit.ru). And, in the next two years, the number of Internet users in Latin America is expected to grow from 8.5 million to about 34 million. The number of Latin American websites, most of which are operated by businesses, could triple in the next year to over 500,000 (Smith, Malkin, Katz, & DeGeorge, 1998).

In Asia, estimates place the total number of Chinese online in Hong Kong, Taiwan, and Singapore at 2.6 million (Global Reach, 1998). The number of users in China almost doubled (620,000 – 1.175 million) from late 1997 to mid-June, 1998 (Williams, 1998). Some estimates predict there will be 20 million Internet users in China by the year 2000 (Ramo, 1998). As these few examples help illustrate, although ICT access is still chiefly available to citizens of developed countries; such access is fast becoming possible in developing countries worldwide. ICT Access in Formal Education Although no comprehensive data on ICT in schools worldwide apparently exists, it is clear from many national examples that schools are also increasingly being equipped with ICT.1 It is also apparent that ICT equipment and Internet connectivity is still much more abundant in North American schools than elsewhere (Genius Newsletter, 1997a). In the United States, the ratio of students per computer dropped from 63:1 to 6:1 from 1985 to 1997 (Market Data Retrieval, 1998) while the number of schools with internet access has grown from 35% in 1994 (U.S. National Center for Education Statistics, 1996) to 72% in 1997 (QED's Educational Technology Trends, 1997).

4 In Africa, the Creating Learning Networks for African Teachers project, part of the UN’s Harnessing Information Technology for Development initiative mentioned above, will equip a maximum of four teacher training colleges (TTCs) in each of 20 African countries with a computer and full access to

the Internet. The project will also fund teacher training curriculum development and the creation of 20 national educational WWW sites (UNESCO, 1998).

In Europe, more than 80% of schools in Solvenia have access to the Internet – 93% of secondary schools and 80% of primary schools – which is similar to the percentages of developed countries. Nearly two-thirds of secondary schools have a website (Research Internet in Slovenia, 1998). In the United Kingdom, the pupil to computer ratio is 16:1 in primary schools and 9:1 in secondary schools, while 43% of schools in the United Kingdom are connected to the Internet (British Educational Suppliers Association, 1998).

The British Government plans to connect all schools, colleges, universities, libraries, and as many community centers as possible to the Internet by 2002 (United Kingdom Department for Education and Employment, 1997). In Germany, the Schulen ans Netz initiative (http://www.san-ev.de) begun in 1996, will connect 10,000 schools to the Internet by mid1999. As of late 1997, of approximately 6,500 were connected and 1,700 had their own website (Schulen ans Netz, 1997). And in Italy, a national program in 1995 resulted in 120 schools being supplied with multimedia equipment.

Last year, plans were announced for the installation of computer and multimedia facilities in 15,000 Italian schools to be carried out by the year 2000. At the end of the programme, approximately 25% of all Italian state schools will have access to on-line facilities and the Internet and will be equipped with advanced hardware and multimedia educational software (Genius Newsletter, 1997b). In Asia, similar developments are taking place. In Japan, as of 1997, over 94% of pubic schools were computer-equipped and 10% were connected to the Internet. The Government plans to provide a pupil to computer ratio of 2:1 in middle schools and 1:1 in high schools by 1999. All of the public schools in Japan will be connected to the Internet by 2003 (Sekiguchi, 1998).

In the People's Republic of China, the central government will increase funding for basic, vocational and higher education projects over the next two years. These plans include strategies to make increasing use of Internet-based educational programs (Ning, 1998) In South America, in 1993, the Chilean government established the Enlaces (Links) project to connect schools and related institutions to Chile's national computer network. By 1996, over180 primary schools and 62 secondary schools had been connected and, by the year 2000, the Chilean government plans to have 50% of the 8,250 primary schools and 100% of the 1,700 secondary schools connected. The Enlaces initiative also includes equipping schools with computers and a combination of locally produced educational software and commercial products that are available in Spanish language versions (Potashnik, 1996).

In New Zealand, These few examples serve to illustrate that efforts to provide ICT and Internet access to teachers and students in developed and developing countries around the world can be expected to continue and accelerate until most, if not all, schools are equipped and connected in the next century. 5 ICT Access in Informal and Non-Formal Education Informal and non-formal education refers to educational activities and programs that are offered outside of formal educational institutions, including those offered by libraries, museums, community schools and centers, zoos, planetariums, commercial companies, and many other organizations. Informal and non-formal education institutions, too, are increasingly being equipped with ICT and connected to the Internet.

At present, about 20% of libraries in the United Kingdom are connected to the Internet. The British government's

National Grid for Learning initiative will connect all British libraries and museums to the Internet (United Kingdom Department for Education and Employment, 1997). In the United States, a 1998 survey sponsored by the American Library Association found 73% of the nation's public libraries offered basic Internet access to the public (American Library Association, 1998). Many public and privately funded museums are offering ICT-based learning opportunities. For example, the Computer Museum's website (http://www.tcm.org) offers activities designed to help individuals learn about computers.

The British Natural History Museum, as part of a European Union funded project to enable multimedia applications such as virtual museums and galleries to be accessed from remote locations, has constructed a virtual model of the Endeavour, Captain Cook's (an English explorer) ship. The ship, as well as virtual reality objects of seabirds and other animals encountered by Cooke on his voyages (http://www.nhm.ac.uk/VRendeavour/ index.htm), are available on the Web. And, in a joint 6 provide a clearer picture of why the use of ICT in education can be expected to continue to grow. Integration of Multiple Media Because of advances in digital technologies, it is now possible to integrate multiple media into single educational applications. Multimedia applications on CD-ROMs and websites may incorporate text, pictures, audio, graphics, animations, simulations, full-motion video, and links to other software or websites greatly enriching the learning experience.

For example, Astronomy Village: Investigating the Universe is a CDROM-based multimedia program developed at the NASA Classroom of the Future (http://www.cotf.edu) that contains ten complete four-week-long investigations for secondary students. Multimedia tools available on the CD-ROM include an image-processing program, an image browser, a telecommunications program for accessing the World Wide Web, a star life cycle simulator, an orbital simulator, and a 3-D star simulator. Multimedia resources include 85 minutes of digitized video clips; more than 300 images from the Hubble Space Telescope and other instruments; 12 illustrated audio lectures by astronomers discussing their work; over 100 computer animations and graphics; and 180 full text documents such as book chapters, NASA publications, and articles from astronomy journals and magazines.

Interactivity Earlier technologies used for instruction were passive in nature. That is, the delivery of instruction required no action on the part of students beyond listening, watching, and perhaps taking notes. Such ICTs were one-way channels of instructional delivery. New ICTs give the student and teacher the ability to control, manipulation, and contribute to the information environment. On the lowest and least valuable level, this may simply mean the student controls the pace and order of a presentation. But much more is possible. Using ICT students may not only make choices about the pace and order of a presentation, but may choose topics; take notes; answer questions; explore virtual landscapes; enter, draw or chart data; run simulated experiments; create and manipulate images; make their own multimedia presentations, communicate with others, and more (Aldrich, Rogers, & Scaife, 1998).

Flexibility of Use Previously, ICT-use required students to be grouped together in a controlled environment at a specific time and location. With some technologies, for example radio and television, use was rigidly tied to schedules developed by people far removed from the day-to-day functioning of the classroom. New ICT applications have given rise to the term "anytimeanyplace," a reflection of the flexibility possible in using ICT to support teaching and learning. One outgrowth of this flexibility has been the development of "virtual" educational experiences. A virtual experience refers to educational situations in which distance and time separate the teacher and students, who use ICT to interactively to share resources, communicate, and learn. Virtual education allows students to study at their own time, place and pace. In essence, a virtual education means having educational transactions accessible 7 from the home, workplace, or anywhere that the student chooses to be.

Virtual classrooms, schools, colleges, and universities offering classes by email, computer-mediated conferencing (CMC), videoconferencing, or websites, or combinations of these technologies, are proliferating. We will say more about virtual education later. Connectivity Perhaps the most powerful feature of new ICTs is connectivity. Prior to the 1990s, computers in educational settings were seldom connected to local area networks (LANs) or the Internet. With the widespread adoption of LANs, decreasing telecommunications costs, increasing bandwidth, and the invention of the World Wide Web, educational access to the Internet is becoming commonplace. If equipped with a computer, appropriate software, and Internet access, students and teachers have access to every other person on the planet who has an Internet account, hundreds of thousands of information archives, and millions of webpages of educationally relevant content (cf. http://www.classroom.net/grades).

These four dimensions – integration of multiple media, interactivity, flexibility of use, and connectivity – distinguish digital ICT from previous technologies. Because of these differences, educators are finding powerful new ways to integrate digital ICTs into the curricula.

EFFECTIVENESS

Perhaps the most important question about ICT is how effective is its use in education? To answer this question one must consider three aspects. How effective is ICT-mediated instruction when compared to traditional face-to-face instruction? What does ICT enable that would not otherwise be possible? And third, are ICT worth their costs? ICT-Mediated Instruction The first question to be considered about the effectiveness of ICT in education is what, if any, impact ICT-mediated instruction has on student performance. ICT-mediated instruction refers to instruction delivered via a technological channel such as television, radio, or a computer and network. ICT-mediated instruction can be synchronous, with both the instructor and the student participating simultaneously.

For example, instruction may be delivered via desktop videoconferencing by a teacher located at a university to employees at widely separated companies. ICT-mediated instruction may also be delivered asynchronously, with the instructor and student participating at different times. Instruction based on teaching materials placed on a website does not requiring simultaneous participation. Or synchronicity may not matter, as when self-contained instructional materials are packaged on a CD-ROM. In this case, the instructional designer may have developed the materials months or even years before the student uses them and communication between the two is impossible.

Early studies of ICT-mediated instruction's effect on student learning have been characterized as the "no significant difference" phenomena (cf. http://www2.ncsu.edu/oit/nsdsplit.htm). That is to say, whatever medium of instructional delivery – film, radio, 8 television, telephone, or computer – was used, no significant difference on performance measures was found between students receiving ICT-mediated instruction and those receiving traditional face-to-face instruction in a classroom.

Both groups perform equally well. Studies focusing on the use of computer-mediated instruction conducted in the 1980s found more positive results. In a meta-analysis of over 500 individual studies, James Kulik (1994) found:

1. Students usually learn more in classes in which they receive computer-based instruction …

2. Students learn their lessons in less time with computer-based instruction …

3. Students also like their classes more when they receive computer help in them …

4. Students develop more positive attitudes toward computers when they receive help from them in school …

5. Computers do not, however, have positive effects in every area in which they were studied.

The average effect of computer-based instruction in 34 studies of attitude toward subject matter was near zero … (as cited in Glennan & Melmed, chap. 2, 1995) Kulik’s meta-analyses were conducted on studies of computer use prior to the 1990s. Such use was often limited to drill and practice and tutorial software programs.

In the 1990s, use of ICT in schools is moving toward engaging students in “authentic” learning tasks in which students use computers, software, and network access to simulate events, communicate, collaborate, analyze data and access information resources. For these applications of ICT in schools, the research data are less extensive. However, some individual studies have been conducted that demonstrate positive learning and affective outcomes (cf., Means and Olson, 1995; Software Publishers Association, 1995; and Special Issue on Educational Technologies: Current Trends and Future Directions, 1994).

A recent study by ETS (1998) of student achievement in mathematics and the use of ICT – the first such study to document relationships between student use of technology across the United States and higher scores on a national standardized test – concluded that “technology does matter to academic achievement, with the important caveat that whether it matters depends upon how it is used” (chp. 4).

In another recent study undertaken by the Bertelsmann Foundation (http://www.stiftung.bertelsmann.de) of students in a German school and a school in the United States concluded “that the use of media and technology improves learning outcomes, instills key qualifications for the information age, and increases motivation” (Bertelsmann Foundation, 1998). And finally, one concern often expressed about ICT is that its use will isolate students from each other and from their teachers. In a 10-year longitudinal study undertaken by Apple Computer, “Dispelling widespread myths, the researchers found that instead of isolating students, access to technology actually encouraged them to collaborate more than in traditional classrooms. And instead of becoming boring with use, technology was even more interesting to students as they began using it for creating and communicating” (Apple Computer, Inc., 1995).

It appears, therefore, that ICT, properly used, may enhance and increase communications between people. 9 In conclusion, evidence has consistently shown ICT-mediated instruction using conventional teaching methods is as good as traditional face-to-face instruction and, in the case of computer-based instruction, may in select instances improve student learning and attitudes towards learning. However, the picture is less clear – but promising – for more sophisticated uses of ICT in the classroom, especially for the host of applications and methods that support “constructivist” learning, in which students are encouraged to work in rich environments of information and experience to build their own understandings about them.

Worldwide, research into the effectiveness of ICT-mediated instruction is continuing and should provide a clearer picture of the effectiveness of ICT in supporting constructivist pedagogy. For example, as part of the Helsinki 2000 project, Finnish investigators are conducting a five-year, multi-disciplinary investigation focused on analyzing innovative pedagogical practices through intensive case studies on computer-supported collaborative learning (Hakkarainen, Halinen, Lipponen, Momaki, & Lehtinen, 1999). ICT-Enabled Education A second way to assess the merit of ITC-use in education is to consider what, if anything, such use enables students and teachers to do that they would not otherwise be able to do.

To explore this question, we consider five aspects of the educational use of ICT – supporting new pedagogical methods, accessing remote resources, enabling collaboration, extending educational programs, and developing skills for the workplace. Supporting New Pedagogical Methods Modern constructivist educational theory emphasizes critical thinking, problem solving, “authentic” learning experiences, social negotiation of knowledge, and collaboration – pedagogical methods that change the role of the teacher from disseminator of information to learning facilitator, helping students as they actively engage with information and materials to construct their own understandings.

That is, students learn how to learn, not just what to learn (cf. Forman & Pufall, 1988; Newman, Griffin, and Cole, 1989; Piaget, 1973; Resnick, 1989; Strauss, 1994). ICT has the potential to be used in support of these new educational methods, as tools enabling students’ learning by doing. ICT can make it possible for teachers to engage students in self-paced, self-directed problem-based or constructivist learning experiences; and also test student learning in new, interactive, and engaging ways that may better assess deep understanding of content and processes (cf. Strommen & Lincoln, 1992; U.S. Department of Education, 1993). Two examples may help illustrate how ICT can support constructivist teaching methods.

Computer Supported Intentional Learning Environments (CSILE), developed at the Ontario Institute for Studies in Education, is a network system that provides support for collaborative learning and inquiry within a school. CSILE

(csile.oise.utoronto.ca/intro.html) promotes student interaction through referencing, connecting ideas, sharing authorship, and "building-on" the work of others to advance knowledge. The central feature of CSILE is a "communal" database into which students can enter text and graphics, and can read, add to, and comment on other's work.

The commercial version of CSILE, Knowledge Base, is being used in both work and educational settings in Canada, Japan, the United States, Finland, and the Netherlands.

The Physics Teaching Studio, pioneered at the Rensselaer Polytechnic Institute (http://www.ciue.rpi.edu/Studioteaching.html) in the United States, incorporates the systematic use of ICT in a cooperative learning environment for instruction in undergraduate physics. Laboratory data acquisition and analysis tools are embedded into a hypermedia text that introduces scientific topics, links the students to related materials, and poses questions for the students to answer with the ICT tools. Studio courses emphasize a hands-on, learning by doing approach engaging students in various problem solving and active learning sessions (Wilson, 1997. Improved assessment tools can also be developed using ICT.

Such assessments can engage students in tasks that require data manipulation, simulation or other interactive acts of knowledge construction. Viz Quiz is a multimedia program that allows students to take a chemistry quiz at a computer, but with the added advantage that color graphics, animations, and video clips can be included in the questions. In addition to multimedia capability, such programs can provide hints, remedial feedback, worked out solutions or explanations, and instantaneous grading.

However, although ICT offers the opportunity to construct powerful learning experiences, it is pedagogically neutral. That is, instead of being used in the ways described above, ICT can be used in support of traditional teaching methodologies like the large group lecture, student note taking, and examinations (cf. Hunt, 1998). Teachers can use a computer and projector to show slides to illustrate a lecture, students can use laptop computers to take notes during the lecture, and multiple choice quizzes about the content of the lecture can be put on a website. How these new ICT tools and resources will be used is a human decision, not inherent in the technologies themselves. Accessing Remote Resources As previously mentioned, connectivity is one of the main differences between older and new ICTs.

Below, we discuss two aspects of connectivity – access to material and to human resources. Historically, information resources at libraries, schools, and universities have only been available within the walls of these institutions, in a wide variety of physical media, at certain times of the day, and in limited quantities. Because of advances in ICT, it is no longer necessary for students and teachers to be at a certain location at a specific time to acquire a physical object. The Internet represents the greatest collection of human knowledge ever assembled, and it is available to every student and teacher properly equipped with ICT.

An unlimited number of digital representations of physical objects can now be made available to students at any time and from any place. Digital library initiatives are being undertaken in countries around the world that will provide collections that are electronically accessible of the Internet including printed works (e.g., textbooks, journals, illustrations, maps, charts and graphs), photographs, films and 11 videotapes, paintings, 3D models, graphics, animations, software, reference materials, audio files, and so forth. A joint effort between the

European Union and the National Science Foundation in the United States is exploring international collaboration on research to develop such libraries (Schauble and Smeaton, 1998). Specialized collections of digital information are also being created. For example, the entire works of William Shakespeare may be accessed, searched, and downloaded from a website at the Massachusetts Institute of Technology (MIT) (the-tech.mit.edu/ Shakespeare/works.html).

Web-based language dictionaries (cf. dict.leo.org/dict/ dictionaries.html), such as the LEO English/German Dictionary (dict.leo.org/dict), provide a means to translate words and phrases from one language to another. The Louvre Museum's website (mistral.culture.fr/louvre) offers visitors a virtual tour and access to digitized images of major works from its collection.

The NASA Image eXchange (nix.nasa.gov/nix) offers access to hundreds of thousands of images taken by U.S. spacecraft of the Earth, the planets, moons, asteroids, and other extra-terrestrial bodies. Thousands of websites now exist that contain collections of high quality curriculum guides, lesson plans, and instructional activities.

For example, the United Nations Cyber School Bus website (http://www.un.org/Pubs/CyberSchoolBus) contains teaching units on urbanization, disease, the environment, and women and politics, as well as interactive games, maps, databases, and quizzes. Specialized websites designed to provide information and assistance in specific subject areas are also proliferating.

Lingu @ NET is a website developed by the British government to provide "quality-assured resources for language teachers and learners worldwide" (http://www.becta.org.uk/projects/linguanet/ lingabout.html). And finally, remote access to expensive scientific instrumentation is also possible. In the United Kingdom, the Virtual Microscope (http://www.open.ac.uk/OU/ Showcase.html) of the Open University can be used by students to view slides over the Internet (or from a CDROM version).

The Hands-On Universe project (hou.lbl.gov/ index.html) at the Lawrence Berkeley National Laboratory, co-funded by several U.S. government agencies, has developed and piloted an educational program that enables high school students to request their own observations from telescopes at professional observatories. Students download digital images to their classroom computers and use powerful image processing software to visualize and analyze their data. This ability to access remote resources and use them locally, although not without negative aspects (see “Significant Issues”), fundamentally changes the quantity, nature, and potential uses of information resources available for educational purposes. In addition to efforts to digitize existing physical resources, many new information resources (e.g., websites, digital images, electronic journals and newsletters) are being created which can only be accessed electronically.

As digital representations of physical resources are created, and as more information resources are distributed only in digital format, it will be critical that students and teachers have ICT access. Enabling Collaboration Not all resources are inanimate. ICT enables educational collaborations between individuals and groups of people. Such collaborations may take place locally or between people in widely separated geographical locations. They may be temporary or long-term. Students 12 may collaborate with peers in other schools, teachers may collaborate with university professors, members of the local business community may serve as mentors to students, scientists in government agencies may work with school children, and so forth. Only educational usefulness and access to ICT limit the possibilities.

Email, computer-mediated conferencing, and desktop videoconferencing are all being used to support collaboration between individuals and groups. Collaborations are also taking place by means of real-time chat systems (http://www.idiom.co.uk/intchat.htm); whiteboards (http://www.sisweb.com/math/whiteboard/); newsgroups (http://www.peg.apc.org/ ~iearn/works.htm); computer-mediated conferencing (CMC) (http://www.ascusc.org/jcmc/); and specialized software like CaMILE: Collaborative and Multimedia Interactive Learning Environment (http://www.cc.gatech.edu/gvu/edtech/CaMILE.html) and The Knowledge Integration Environment (http://www.kie.berkeley.edu/KIE.html).

Other applications include MUDs (Multi-User Domains) MOOs (Multi-user domain, Object Oriented), and MUSHs (Multi-User Shared Hallucinations). Such applications are Internet-accessible, text-mediated virtual environments in which participants can both interact with others as well as help construct the common virtual space. At the University of California, Berkeley, classes in language, literature, linguistics, law, and communications are making use of such applications (moolano.berkeley.edu). Combinations of these ICT applications are also frequently used in educational programs. Online Experts Many organizations offer “ask an expert” services. For example, students may send inquiries about scientific topics to working scientists at the Canadian Centre for Marine Geology of Dalhousie University (is.dal.ca/~stanet/ask.html) and the U.S. Argonne National Laboratory (newton.dep.anl.gov/#AAS).

In other examples, online experts offer advice in health (http://www.goaskalice.columbia.edu/index.html), weather topics, (http://www.kark.com/kark5a.html), and construction engineering (http://www.siue.edu/ENGINEER/CONSTRUCT/conclub.htm). In an extreme example of how ICT can bridge distance to enable students to access remote expertise, last spring students from four universities in the U.S. and Canada and discussed physiology experiments with astronauts orbiting the Earth aboard the space shuttle Columbia (Chronicle of Higher Education Online, 1998).

Online Mentors ICT can also enable mentoring programs to provide one-on-one guidance to individuals by well-established members of a particular community. Such virtual collaborations between individuals are an effective ways for senior members of a community to teach, inspire, and support newcomers. Mentor High School in the United States offers an electronic Quest Forum in which freshmen students may discuss course options with students in the senior class (http://www2.mhs.k12.oh.us/quest/forum). In a project intended to increase retention of new teachers in the profession, the U.S.

National Science Teachers Association is providing first year elementary teachers with experienced teachers as mentors (live.nsta.org/reports/article2.htm). And in a final example of how ICT can support mentoring,, the Asian American Psychological Association (AAPA) offers an electronic discussion group on which, according to the organization's president elect Richard Suinn, 13 "the elder researchers are logging on in a very constructive and supportive way, providing information and support to younger researchers" (Murray, 1998). Virtual Learning Communities ICT makes it possible to engage people in widely dispersed locations in "virtual learning communities." Virtual learning communities are learning groups based on shared purpose, not artificial distinctions of location or age.

Through ICT, learners can be drawn together from almost anywhere, and they can construct their own formal or informal learning groups. Such communities may transverse barriers of time, geography, age, ability, culture, and social status. ICT that supports such efforts can be as simple as email or as sophisticated as desktop videoconferencing systems. In an example of how email is being used to enable virtual learning communities, a course titled International E-Mail Debate is being offered by professors at universities in Turkey, the United States, Germany, and the Czech Republic to promote writing skills across cultures and enhance intercultural awareness. Students enrolled in the course debate position papers on timely and relevant topics using E-mail.

Virtual Design Studios, begun in 1993, are collaborations between teams of Architecture students in universities worldwide (arch.hku.hk/projects/vds/). Teachers and students, on different continents and in different time zones, work on a common design project using computer-aided design systems, email, a central database, and video-conferencing. Participants use the World Wide Web to display their designs and a virtual international jury of architects and teachers judges the relative merit of the work.

Past student projects included re-designing housing in Shanghai and designing a Center for Cultural and Religious Studies in Japan. A similar effort took place in 1996 between students and teachers at Union College (USA), METU (Turkey), and Queen's University (Canada) (design.me. metu.edu.tr/vds/). Virtual Design Studio techniques are being utilized by other disciplines, such as Engineering (cf. Sclater, Sclater, & Campbell, 1997). The Global Learning and Observations to Benefit the Environment (Globe) program (http://www.globe.gov), sponsored by the U.S. Government, links students, teachers, and the scientific research community worldwide in a virtual learning community to study the global environment. Internationally, GLOBE is being implemented through bilateral agreements between the U.S. government and governments of partner nations. As of December 1998, thousands of schools in 74 countries have registered as participants.

In the GLOBE program, scientists design protocols for specific measurements they need for Earth Science research that can be performed by K-12 students. Teachers are trained in the GLOBE protocols and teach them to their students. Students make the measurements, enter data via the Internet to a central data archive, and the data becomes available to scientists and the general community. Scientific visualizations of the data are provided over the Internet. Students benefit by having a "hands-on" experience in science, math, and technology, using their own local environment as a learning laboratory.

Students also benefit from the opportunity to communicate with their peers around the world, thus increasing not only their environmental understanding but also their understanding of other cultures and their sense of global community. 14 Beginning in 1995, a series of online “Quest” projects have brought together students and teachers together around the world into a virtual community to learn about specific topics framed in an interactive learning expedition. For example, during Maya Quest, a 1995-96 project, over 1 million students, teachers, and others from around the globe followed the progress of a five-rider scientific bike expedition among Mayan ruins in Mexico and Central America, learning about the ancient Mayan civilization and learning from on-site archaeologists.

The bicyclists carried laptop computers and a satellite dish to connect to the Internet. Students voted on team decisions, explored 21 Maya sites and were virtually on hand for several major archaeological discoveries. The original Maya Quest website (no longer available) received over a 1.2 million hits in 90 days. It offered team updates, photographs, teachers' guides, and direct interaction with eight of the world's top archaeologists. The company has since offered educational scientific expeditions to Africa and the Galapagos Islands (africaquest.classroom.com/gqmarket/gqmarket.asp). Other organizations are offering online learning adventures for teachers and students.

The Jason Project (http://www.jasonproject.org) and the Magellan Global Adventure (http://www.adventureonline.com/ga/index.html) are two other examples of such online adventures, explorations, and expeditions. The SIMULAB Project, supported by the European Union, involves web-based communication between language students across national boundaries. Using specialized software, teachers can create Internet-based simulations for role-playing activities in language learning. The simulations, incorporating email, chat, and online creation and editing of documents, are thought to motivate oral and written communication amongst the participating groups, while students are guided through scenarios relevant to the country of their chosen language (http://www2.echo.lu/telematics/education/en/projects/files/simulab.html).

The UNICEF Voices of Youth website (http://www.unicef.org/voy) offers opportunities for teachers and students to participate in discussions on current global issues, such as the effects of war on children; take part in interactive global learning projects, and exchange experiences about the use ICT in education. Home/School Communications Although such virtual learning communities can span the globe, they can also be formed locally. For example, in the U.S., students, parents, teachers, and administrators in the Los Angeles Unified School District's Project REBUILD have joined together into a virtual learning community with the objective of improving the performance of Limited English Proficient (LEP) students. Staff at 11 schools are using interactive videoconferencing over computer networks to jointly plan lessons and team-teach from different sites.

All students in Project REBUILD schools, mostly minority children, are provided with access to the Internet and electronic mail in their classrooms and from their homes. Homework assignments are placed on the web and informal parent-teacher conferences take place electronically whenever necessary. Staff members at the school sites receive continuing professional development instruction and consultation via videoconferencing from staff at the Center for Language Minority Education and Research at California State University Long Beach. Among other reported benefits, students in the program have made substantial gains in English reading proficiency (Green, 1998). 15 In the United Kingdom, Microsoft, Comtel and International Computers Limited (ICL) have funded the Highdown Information Hub (http://www.highdown.berks.sch.uk) which connects homes and schools via the Internet.

Parents are able to send email to their children at school during the working day, view projects that their children are working on, and electronically converse with teachers, opening up new learning opportunities by enabling close collaboration between parents, students, and teachers. Extending Educational Programs ICT makes it possible to extend the reach of educational programs in two important ways. First, ICT makes it possible to deliver educational programs anywhere in the world. Second, ICT also can help individuals learn throughout their lifetime. Distance (Distributed) Education Distance education programs, also known as “distributed” education programs, are those in which the teacher and students are physically separated, and teaching and learning takes place by means of single technologies or combinations of ICTs. In the past, such programs made use of print, radio, and television. Now, new ICTs are driving changes in these traditional “open” or distance education programs.

Such programs are increasing using the Internet and the World Wide Web for the delivery of courses. For example, the International Francophone Consortium of Distance and Open Learning Institutions (CIFFAD), a consortium of open and distance learning institutions spread over 49 countries, of which 80% are in developing nations, has recently entered into a phase of reengineering to make use of new ICTs. The group aims to provide at least one hundred access points to the Internet per year in member establishments with the major part of the consortium having access to the network by the end of 1998 (Simard, Lopez, & Fofana, 1998). In an initiative making use of a combination of virtual and traditional educational programs, Singapore's two leading research universities – the National University of Singapore and Nanyang Technological University – and The Massachusetts Institute of Technology in the U.S. recently signed an agreement to “create a new global model for long-distance engineering education and research" ("MIT and Singapore Launch Global Educational Collaboration," 1998).

The jointly developed degree programs will enroll their first students in July 1999, and will be created and delivered by instructors from the three institutions, using a combination of faculty and student exchanges and state-of-the-art communications technology. Typically, distance education courses have been offered as supplementary programs by campus-based educational institutions. Now, however, digital ICTs have stimulated the creation of "virtual" non-profit and for-profit educational institutions that exist partially or only in "cyberspace" and whose programs are offered entirely by means of ICT. Such efforts are making it possible for ICT-equipped individuals located anywhere to participate in educational programs. The Western Governors University (http://www.wgu.edu) is an example of a "virtual university," a university that has no physical campus. WGU, initiated in 1996 by the 16 governors of 18 of the Western United States, is a competency-based, degree-granting, virtual university: "a 'cyber' university that is not bound by its location because it doesn't have a campus in the physical sense. By using the latest technology … WGU is able to bring classes to you, regardless of where you are" (http://www.wgu.edu/wgu/about/whatwe.html). WGU is currently offering more than 300 college-level distance learning courses from 30 affiliated universities and education providers. WGU has forged international alliances with the China Internet Education Center, Tokai University in Japan (http://www.u-tokai.ac.jp), University of British Columbia in Canada (http://www.ubc.ca); The Open University in the United Kingdom (http://www.open.ac.uk); and the Virtual University of the Monterrey Institute of Technology in Mexico (http://www.sistema.itesm.mx/english/ uv.htm) to collaborate on the development and delivery of distance learning programs.

(The Virtual University of the Monterrey Institute of Technology enrolls nearly 70,000 students within Mexico and offers 31 baccalaureate, 37 masters, and 7 doctoral programs.) In Germany, the four Baden universities Freiburg, Karlsruhe, Mannheim and Heidelberg recently announced the establishment of that country's first virtual university. The initiative's objective is to establish individual distance learning via e-mail, ISDN or digital television. Within the next five years, the project will receive financial support of 8.8 million marks from the state of Baden-Wuertemberg within the framework of the "Future Initiative Young Generation" (Die "Virtuelle Universität Oberrhein" [VIROR] bündelt Multimedia-Knowhow der Universitäten Freiburg, Heidelberg, Karlsruhe und Mannheim, 1998).

Example, in Africa, the World Bank is funding the development of the African Virtual University (AVU). This effort holds great promise for improving educational access for people on a continent where relatively few enjoy the benefits of education, let alone a tertiary education: Very few African countries have attained primary education for all, despite the fact that many have been independent for some thirty years. At secondary level, the record is even worse, with many African countries able to provide secondary education to only 4 or 5 per cent of the age-group.

Most African countries can boast of less than 1 per cent of the relevant age-group attaining any form of tertiary education, compared to between 25 per cent and 75 per cent in industrialized countries. And those who do attain tertiary education are unlikely to specialize in science or technology. (International Commission on Education for the Twenty-First Century, 1998, p. 206) AVU (http://www.avu.org) completed a pilot phase in 1996-98 and is now moving into an operational phase when it will begin delivering full-fledged undergraduate degree programs in Science and Engineering in January1999. The AVU's programs will be delivered by a combination of ICT including interactive television and the Internet. The program is developing a digital library of scientific engineering as a resource to students and teachers. Virtual educational programs are not limited to postsecondary education.

The U.S. Department of Education has funded the Virtual High School (VHS) project (vhs.concord.org), a collaborative of U.S. high schools that develops and shares web-based courses. During the 1997-98 school year, VHS offered 29 Internet-based, credit-bearing courses to about 500 students in 27 schools located in 10 states. This approach is thought to be particularly useful as many of the participating schools either have no qualified teacher 17 or insufficient enrollment to justify individually offering some of the courses available through the collaborative. In addition to traditional institutions using ICT to enhance or create distance learning programs, commercial companies like Sylvan Learning Systems, Inc, (http://www.educate.com) in the United States and the Wall Street Institute School of English (http://www.wallstreetinstitute.com) in Europe are starting ICT-based for-profit distance education programs.

Although alternate and distance education providers currently make up less than 2% of the postsecondary education market, almost $2 billion dollars has been raised on Wall Street since 1996 to finance such new ventures (Marchese1998). Lifelong Learning Unlike in the past when a person's education took place for a specific period of time during their youth, education is now widely seen as a continuing activity taking place throughout the lifespan. Establishing lifelong learning habits among citizens and providing lifelong learning opportunities has become a major goal of government initiatives worldwide (cf. Hatton, 1998). Lifelong learning is thought to be important for at least two reasons. First, it is no longer possible to master an entire discipline in a few short years.

The amount of information available and the speed at which new information is being created makes this impossible. Consider, for example, that printed scientific information doubles approximately every 10 years. Half of all available scientific information has been published in the last 10 years (Odlyzko, 1996). Second, career changes are becoming more frequent as are changing requirements within individual professions. For example, the People’s Republic of China is facing changes of unprecedented magnitude in its traditional industries, and a large number of workers are being forced to change careers or take early retirement. In order for these industries to survive and to take advantage of market opportunities, the workforce will need to be upgraded to work at higher knowledge levels with new technology (Wu & Qilian, 1998). Because ICT can enable teaching and learning from anywhere at anytime, it is seen as an effective means to provide lifelong educational opportunities. In a recent report, the World Bank’s Consultative Group on International Agricultural Research (CGIAR) noted: In industrialized nations, it is widely recognized that lifelong learning has become essential in a world driven by new science and technologies, with frequent retraining being needed for many professions.

Fortunately, we now have a new tool that makes this type of education much more readily possible. The Worldwide Web is being used as a direct teaching tool that allows virtual classrooms of interacting students and faculty to be created through "asynchronous learning networks." (CGIAR System Review Secretariat, 1998) In another example of how ICT is seen as providing the means of enabling lifelong learning, UNESCO's Learning Without Frontiers (LWF) initiative (http://www.unesco. org/education/lwf/), which has sponsored many conferences, policy documents, publications, and pilot projects focused on lifelong learning:

18 … is geared towards stimulating innovation and exploring alternative pathways/partners/technologies for the provision of lifelong and lifewide learning opportunities, particularly, to those who are currently unreached by or excluded from conventional modes of educational delivery. As part of this challenge, LWF is concerned with exploring how various technologies and approaches can be used to overcome multiple barriers to learning (i.e., age, time, space, circumstance) and to assist with broader development objectives (UNESCO, 1996). Many examples of how ICT is being used to foster and encourage lifelong learning can be found. In Africa, LWF is supporting the implementation of "Multipurpose Community Telecenters" in five countries (Benin, Mali, Mozambique, Tanzania, and Uganda) at which locals may have affordable access to ICT.

By enabling users to share the costs of facilities and support, the Telecentres will offer low-cost means of Internet access as well as information support for literacy campaigns, basic and non-formal education, and information on government programs. The Telecenters will also provide facilities for the generation and exchange of community-based information. In Great Britain, the Department for Education and Employment (http://www.dfee.gov.uk/ dfeehome.htm) has established a "UK Lifelong Learning" website (http://www.lifelonglearning.co.uk) that provides news, reports, and lists of lifelong learning opportunities. Earlier this year, the Dutch government launched a national program for lifelong learning "to ensure that better use is made of the country's intellectual resources." As part of the program, teacher-training colleges will receive extra funding to experiment with ICT (http://www.minocw.nl/english/ press/e9802.htm#art4).

The European Lifelong Learning Initiative (http://www.ellinet.org/elli/home.html) makes use of ICT, "to initiate the dissemination of information, the co-ordination of projects and studies, the mobilisation of actions, people and organisations to bring Europe into the Lifelong Learning Age. It covers all sectors and all countries" (European Lifelong Learning Initiative, 1997). The Asia Pacific Economic

Cooperation (APEC) Forum has established three mechanisms to assist countries across the area to establish lifelong learning projects: the creation of a database of Asian scholars, researchers and practitioners involved with lifelong learning issues and programming across the region; the development and publication of a book of papers on lifelong learning policies, practices and programs across the Asia Pacific region; and a lifelong learning conference for APEC members to discuss issues identified in the book (http://www.apec-hurdit.org/lifelong-learning-project.html).

Developing Skills for the Workplace After leaving school to embark on a career, young people can expect the day-to-day practice of every discipline to be affected by the use of ICT. In the future, economic competitiveness, employment, and personal fulfillment may no longer be based on the production of physical goods. Personal and national wealth creation may be linked to the production and dissemination of knowledge and depend on research, education and training, and on the capacity to innovate.

Having advanced ICT skills and knowing how to use discipline-specific applications may help students secure suitable employment and enhance their productivity once employed. Furthermore, as has been noted above, the ability to 19 engage in life-long learning opportunities offered by educational institutions around the world is increasingly dependent upon access to, and use of, ICT. In light of changing perceptions about what constitutes appropriate skills for the modern era, some organizations are promulgating educational standards, attempting to codify what all students should learn about ICT. For example, the National Educational Technology Standards (NETS) project in the United States has released an initial set of national educational technology standards for pre-college students (cnets.iste.org). The NET standards are divided into six categories including "Basic Operations and Concepts," "Social, Ethical, and Human Issues," "Technology Productivity Tools," "Technology Communications Tools," "Technology Research Tools," and "Technology Problem-Solving and Decision-Making Tools" (International Society for Technology in Education [ISTE], 1998).

However, although it can be anticipated that the increasing use of ICT in education and society will change the nature of the knowledge and skills students must acquire in order to compete and contribute in an increasingly ICT-dominated global economy, what skills will be necessary is not clear: What do students need to know and do with technology? Unlike the more stable content and goals we have for other areas of school study, technology continues to change and evolve; with these changes come ever-new goals for how technology should serve learning, and what students should know about technology.

A review of the "prevailing wisdom" about appropriate technology use since the early 1980s takes one down an ever-turning road that includes programming in BASIC, then with LOGO; and on to drill and practice applications on integrated systems; wordprocessing and curriculum-specific tools like history databases, simulations, and microcomputer-based labs; then multimedia; the Internet; and now Web page design. While there may be some logic to this progression, the reality is that, just as educators get their arms around one approach, with the attendant investments in software, training and possible curricular readjustments, the messages about appropriate technology use change. (Fulton,1998a) There does seem to be a growing consensus that all students must achieve “Information literacy”: “It is the task of general education to provide every girl and boy with the versatile basic skills in acquiring, managing and communicating information which are necessary in the information society and essential for successful further study" (Ministry of Education, Finland, 1995).

The American Library Association has outlined seven steps representing the basic elements in an information literacy curriculum: Defining the need for information, initiating the search strategy, locating the resources, assessing and comprehending the information, interpreting the information, communication the information, and evaluating the product and process (American Library Association, 1996). Anderson and Bikson (1998), in a discussion of generic skills that "information society literate" citizens should have, suggest three categories into which such skills might be categorized: Connectivity, Logic, and the Structuring of Data and Information. 20 It is clear that new skills and knowledge will be necessary to compete and contribute in a global "knowledge society." However, because of the rapid pace of change of ICTs, it is less clear what skills can be taught to today's students that will still be relevant by the time they graduate and enter the workforce.

Focusing on concepts like "information literacy," rather than on specific technologies or applications, may be essential in planning and developing new curricula. Cost-Effectiveness

The third issue we consider when assessing the effectiveness of ICT in education is the question of cost-effectiveness – information is of critical importance, especially to developing countries with fewer resources to invest. However, assessing the cost effectiveness of ICT in education is difficult, if not impossible, for at least four reasons – lack of meaningful data, variability in the implementation of ICTs, difficulty of generalizing from specific programs, and difficulty of assessing the value of qualitative educational differences. In addition, cost-analyses do not consider the societal and economic consequences of not investing in ICT for education. First, direct comparisons between traditional and ICT-based educational programs are hard to make because meaningful data are lacking.

When considering the costs associated with ICT use, what variables are included in such studies vary widely. For example, in addition to hardware and software costs such an analysis may or may not take into account factors such as teacher training, support personnel, facilities renovation, security systems, insurance, and so forth. Furthermore, many institutions making use of ICT in their programs simply do not collect such data. Potashnik and Adkins (1996) reported problems in conducting a costanalysis in developing countries because of the lack of local “effective efforts to do real world cost analysis” and the difficulty “to obtain the kind of information we would have liked to include in our cost analyses”. Second, there is the question of which technologies and applications to compare. The costs associated with any ICT-based educational program may “merely indicate the choices that have been made, not the choices that are possible” (Twigg, 1996). Evaluating the costeffectiveness of email-based courses will return a different result than comparing courses using videoconferencing technologies, although the educational goals may be similar.

Making judgments as to the cost-effectiveness of ICT-use in general from the analysis of particular programs is difficult. Third, as has been noted earlier, ICTs are not single technologies or applications, but an array of possibilities. Many ICT-based educational programs use a combination of technologies and applications, making the analysis of costs and comparisons with other programs even more difficult. This is further complicated because of the rapid evolution of ICT and changes in its uses in education. Studies typically take a long time to complete and longitudinal studies take years. Such efforts may be doomed to failure because the subject under study is a “moving target.” And finally, there is the question of what metrics are useful in measuring "effectiveness." Is "effectiveness" determined by units of instructional time, by student retention rates, by performance on assessments?

Quantitative measures are easier to construct but may not ultimately tell us much. Qualitative differences may ultimately be more important in 21 assessing the cost-effectiveness of ICT, but may not be measurable. For example, approaches to incorporating ICT into education can be roughly grouped into three categories – learning about (computer literacy and programming), learning by (drill and practice and tutorial software), and learning with computers (collaborating with remote groups, conducting research over the Internet). Are all three curricular approaches of equal value? In more recent years, the third approach, integrating ICT-use throughout the curriculum, has been the focus of reform: "Integrating or integration means that emerging technologies must be interwoven into the total fabric of education to make technology and education one" (Bailey & Lumley, 1994, p.11, as cited in Murphy & Gunter, 1997).

But how does one measure this educational goal? What constitutes effective and sufficient integration? Also, how can "cost-effectiveness" of ICT-equipped versus non-ICT-equipped classrooms be assessed when taking into account less tangible benefits like the ability to access remote resources or to collaborate with students in other countries? Cost Comparisons None-the-less, even in the face of such obstacles, attempts to establish the relative costs of ICTs in education have been reported. In general, these studies find that the use of new ICTs is more expensive that instruction delivered by older technologies like print and radio, but less expensive than instruction delivered by television.

For instance, Potashnik and Capper (1998) reported: Print, audiocassettes, and prerecorded instructional television (lectures) are the lowest-cost technologies for small numbers of students (fewer than 250), while radio requires 1,000 students or more to achieve comparable per-student costs. Computer conferencing is a low-cost approach to providing interactivity between teachers and students, but live interactive broadcasts and video conferencing are still very highcost technologies, regardless of the number of students enrolled. (Potashnik & Capper, 1998) In a World Bank report (1998) on education and ICT in Latin America and the Caribbean, the costs of using a computer with an Internet connection in a school was much less expensive per pupil than broadcast television, but substantially more expensive than radio.

It should be noted that even these findings may be misleading because of the variability across regions and individual countries in the cost of Internet access and what such costs mean in the real income of individuals in various countries. As should be clear from the information below, although Internet access is absolutely less expensive in Africa than Europe, the "real" cost to individual users in Africa is much higher: Currently, the average cost of using the Internet for 5 hours a month in Africa is about $60/month.

This contrasts with figures of the Organization for Economic Cooperation and Development (OECD) which estimated recently that 20 hours of Internet access in the U.S. costs $29, including phone and provider fees. Although European charges are more ($74 in Germany, $52 in France, $65 in Britain, and $53 22 in Italy) all of these countries have per capita incomes which are 10 - 100 times greater than the African average. (Jensen, 1998b) "Despite the general lack of cost data that can be used to estimate the cost of information technology projects in developing countries," Potashnik and Adkins (1996) were able to compare the per pupil costs of setting up a computer laboratory in a school for computerassisted instruction in Belize ($78), Jamaica ($89), and Chile ($104) (pp. 13-15).

A similar analysis of the costs of equipping a classroom, not a laboratory, with computers in the United States for computer-assisted instruction yielded a figure of $453.2 (This difference may be explained by variations in human costs as well as a tendency for the data from developing countries to underestimate some costs associated with operating a computer laboratory.) Osin (1998), in a paper on ICT in developing countries, assessed the annual per-student cost of providing computers for instruction in developing countries at $84 USD.

This finding is in close agreement with the study by Potashnik and Adkins reported above. By extrapolating the expenses if 30 computers were used 300 days per year, 10 hours per day, as a resource to raise the skills and education levels of all members of the community, not just students, Osin estimates the cost drops to 34 cents per hour of interaction. He concludes, “There is no alternative system known that may provide the benefits possible by integrating computers in the education system, while at the same time serving the whole community.” (p. 9). Costs of Alternatives Another factor that must be considered when calculating the cost-effectiveness of ICT use is the question of alternatives.

The costs of building sufficient campuses to handle the rising demand for education may be prohibitive. Virtual educational institutions do not require the same campus infrastructure and related costs traditional campus-based institutions must support: The number of places in conventional colleges and universities and school systems will always be limited, reflecting in part the fixed capacities of the campus and the faculty. Developmental and operational costs associated with conventional colleges and universities are high.

By comparison, distance education has lower start-up costs, and much lower operational costs. With "campus-free" distance education, variable costs, once the system is operational, tend to be flat. That is, beyond a relatively small number of students, the costs per student are the same or slightly less. The increasing use of technology to broaden the scope of distance education has great potential for further reducing costs per student. In Chinese Taipei, the distance education-based National Open University, with its budget of NT$800,000,000, accommodates approximately 30,000 adult students each year.

By comparison, the National Taiwan University, one of the larger universities in Chinese Taipei, has an annual budget of $NT3,500,000,000 for its 21,000 students (Ministry of Education, 23 1996). Though gross numbers of this sort beg some level of refinement, the differential costs remain substantial and manifest. (Huang, 1998) The above analysis does not consider that other costs, such as curriculum development and library resources, can be shared across virtual collaborations of institutions thereby lowering the costs to individual institutions.

For example, the Pennsylvania Online World of Electronic Resources (Library POWER) initiative, will make thousands of periodicals and documents accessible over the Internet to state residents, realizing an enormous savings for individual libraries within the state: "If each library were to purchase these subscriptions individually it would cost over US$12 million. We're able to do it for the whole library system for just $1.25 million." (Wired News Report, 1998) Costs to Society And finally, when discussing cost-effectiveness, one must consider the societal costs to developing countries of not preparing their citizens to participate in an information-based global society.

The World Development Report 1998/99 (World Bank, 1998) warns that the global explosion of knowledge may either lift hundreds of millions of the world's poor out of poverty or it may create a widening knowledge gap, in which poor countries lag further and further behind: If knowledge gaps widen, the world will be split further, not just by disparities in capital and other resources, but by the disparity of knowledge. Increasingly, capital and other resources will flow to those countries with the stronger knowledge bases, reinforcing inequality. (p. 14) The Report further recognizes that ICT can play a major role to play in reducing information inequities: This new technology greatly facilitates the acquisition and absorption of knowledge, offering developing countries unprecedented opportunities to enhance educational systems, improve policy formation and execution, and widen the range of opportunities for business and the poor. One of the greatest hardships endured by the poor, and by many others who live in the poorest countries, is their sense of isolation.

The new communications technologies promise to reduce that sense of isolation, and to open access to knowledge in ways unimaginable not long ago. (p. 9) And, as Potashnik and Adkins (1996) have pointed out, “even in countries which do not believe in the cost-effectiveness of information technology as a tool for mass education, it is important that they begin acquiring experience using this technology for educational purposes. Otherwise, educators in developing countries will be marginalized in the international dialogue on education" (p. 3). In conclusion, assessing the effectiveness of ICT in education is a difficulty, multidimensional endeavor. When comparing ICT-mediated instruction with face-to-face instruction, it seems clear that ICT-mediated instruction is at least as effective. When considering what ICT-use enables educationally, it seems equally clear that ICT-enabled 24 education has a distinct advantage over traditional methods in its ability to support new pedagogical methods, provide access to remote resources, enable collaboration, reach more people less expensively, and reach them throughout their lifespan.

When considering whether ICT is "cost-effective" in educational settings, a definitive conclusion may not be possible for a variety of reasons. However, when considering the alternative of building more physical infrastructure, the cost savings to be realized from sharing resources, and the societal price of not providing access, ICT as a means of enabling teaching and learning appears to be an attractive and necessary alternative.

CREATING AN ICT-ENABLED LEARNING ENVIRONMENT

In this section, we will concentrate on the development of ICT-enabled learning environments, specifically on infrastructure, content, teacher education and training, and technical support. Infrastructure In order to make use of digital ICTs schools must be equipped with computers. In order to access the Internet from a computer, schools, homes, libraries, and other educational venues must be equipped with an Internet connection, either by means of the telephone or cable network and a modem or a direct connection. Many creative means to providing computers and building the necessary Internet infrastructure are being explored in countries throughout the world.

Education/Business Collaboration Collaboration, including cost sharing, between education and industry to build ICT infrastructure is becoming commonplace. For example, the Bristol Education Online Network (BEON) project (http://www.education.bt.com/ednews/43beon.htm) and the follow-on Merseyside Education Online Network (MEON)

(meon.eonic.net) are cooperative efforts of commercial companies British Telecom (BT) and International Computers Limited (ICL), local schools, and the University of Exeter School of Education.

These projects seek to examine the impact of ICT on education. ICL is supply multimedia computers and BT the networking and access to remote services and the Internet to a number of schools in the area. As part of these projects, University teacher educators are linked with teachers via desktop videoconferencing to provide continuing professional development. Business-to-Education Technology Transfer One promising approach to equipping schools with computers inexpensively is to transfer the technology from government organizations and businesses to schools.

In the U.S., the Government's Computers for Learning program (http://www.computers.fed.gov) donates surplus federal computer equipment to schools and non-profit educational organizations. Established by Executive Order, the program aims to provide hundreds of thousands of computers for teaching and learning. Other non-governmental programs, such as the non-profit Detwiler Foundation's Computers for Schools (http://wwwnt.thegroup.net/detwiler) and the charitable organization Computers for Children (http://www.computersforchildren.com) in the United States and the industry- 25 supported Computers for Schools program in Canada (http://www.schoolnet.ca/cfsope/welcome_e.html), are soliciting donations of “obsolete” or redundant computers from business, industry, and individuals, and refurbishing them before donating them to schools. As of the summer of 1998, the Detwiler Foundation has placed more than 40,000 computers in U.S. schools nation-wide.

The goal of the Computers for Schools program in Canada is to place 250,000 computers in schools and public libraries by 2001. To date, the program has donated over 70,000 refurbished computers to Canadian schools and libraries. School–University Partnerships Although not primarily intended as infrastructure projects, partnerships between schools and universities often result in new infrastructure development.

These projects typically target university/school connectivity for research, teacher education, and Internet access. As early as 1990, Wilbur and Lambert reported over 1,200 such partnerships in the United States alone. Netdays "Netday" initiatives, characterized as "high-tech barn-raising," are grass-roots efforts by community volunteers to wire classrooms, libraries, and computer labs so that they may connect to the Internet. Organizers of such efforts typically help schools to develop a technical plan that includes instructional goals, network and wiring architecture, network management and technical support, training, and an operating budget.

On a specific day, volunteers from the local community do the physical labor necessary to run network wiring; greatly reducing the costs of providing Internet access within the schools. Netdays began in 1995 as a local initiative in California, but have since become an annual national initiative endorsed by the President of the United States (http://www.netday.org), and have spread to countries throughout the world. For example, Netdays now take place Australia (http://www.netdayoz.edu.au), many European countries, (http://www.netdays.org/ en/projects/country.html), Israel (http://www.netdays.org.il), Japan (http://www.netday.or.jp/index-e.html), New Zealand (http://www.netday.net.nz), South Africa (http://www.netday.org.za), and, in Latin American and the Caribbean, UNESCO is sponsoring a netday initiative (http://www.unesco.org/events/latin/euro_america.html).

Community Networking Although not strictly intended for educational purposes, many Community Networking initiatives have educational components and are worthy of mention. Community networks bring together entire villages, towns or cities into virtual communities to strengthening social ties, promote social participation, promote economic development, and build a sense of civic responsibility. Such initiatives establish affordable, community operated ICT systems that involve local individuals and organizations in learning about electronic communications, and help construct these systems to meet unique local needs.3 26 In an interesting example of how community networking can benefit educational institutions, the International Telecomputing Consortium (http://www.itc.org) is working with schools and universities in China to create school-based community networks. In these projects, participating schools (http://www.itc.org/ chinaprojects.html) establish computer centers with Internet access for use by students and teachers in class.

After hours, the center is open to parents and other members of the community who may not have Internet access. Teachers and students in these schools provide ICT training for members of the community. The school thus becomes the

Internet access point for the entire community with some revenue going back to the school. Technology Grants Another useful method of providing support for ICT in education is the provision of specialized grants to individuals and educational institutions. Such grants programs serve a dual purpose of stimulating innovation in the educational community and targeting scarce resources on particularly promising applications. Many for-profit and non-profit organizations offer such grants to teachers and schools.

For example, the Hewlett-Packard (webcenter. hp.com/grants/index.html), Compaq (http://www.compaq. com /newsroom/pr/pr220698c.html), IBM (http://www.ibm.com /ibm/ibmgives), and Microsoft (academi coop.isu.edu) companies all offer equipment grants to educators. In the United States, the Department of Education's Technology Innovation Challenge Grants annually funds large-scale educational innovations with ICT (http://www.ed.gov/Technology /challenge). Content Beyond equipment and software, appropriate content is necessary to make use of ICT for educational purposes. In this section, we consider a few of the many initiatives related to educational content creation and standards.

Content Creation Content is being created by many organizations including governmental agencies, commercial and non-profit organizations, mainstream and extremist political and religious groups, social clubs, universities, colleges, trade unions, public and private schools, libraries; collaborations between such groups; and individuals.

Although some online content is specifically designed for educational purposes (cf. http://www.EDsOasis.org), most is not. Indeed, the sheer amount of information available on the Internet, the ease with which it may be accessed, and the lack of standards for cataloging such information have created problems of information overload and quality control for parents, students, and educators worldwide. These problems, coupled with the preponderance of Internet-accessible content 27 having been produced by a few developed countries – particularly the United States) – have led many to believe the Internet is a mixed blessing for education (see section below "Significant Issues" for more discussion).

The speed of the development of information overload may be illustrated by the fact that in June 1993 there were only 130 websites worldwide. By January 1997 this number had grown to a staggering 650,000. The number of websites has been more than doubling, sometimes trebling, every year since 1993 and is expected to do so for the foreseeable future. As each website usually contains multiple webpages, it is literally impossible for one person to view every webpage on the Internet. In another example, it is estimated that there were fewer than 100 Chinese webpages in 1994. Today, estimates place the number at over a quarter million offering everything from book reviews to travel guides, and the numbers continue to increase dramatically (Ramo, 1998). Regional Collaboration Countries with similar languages, cultures, or that have migrant populations may be able to economize in the creation of ICT-based content and tools by collaboration.

For example, in Europe, the TOPILOT telematics project involved a management team and 15 school-based partners in the UK, the Netherlands, Belgium, and Germany in the development of a multimedia educational program for fairground, circus, and bargee families within the European Community, all living a traveling life-style. The project developed interactive CDROMs students could use while on the road as well as tools to be used for Internet-based interaction between tutors and students (Dobbeni, Marks, & Botke, 1998).

Schoolnets One approach to facilitating access to appropriate educational content is the creation of a "Schoolnet." Schoolnets, also known as "national education grids," are regional, national or local projects that may include efforts to physically wire schools to information services, but that are fundamentally developed to provide access to appropriate educational content. Schoolnets may contain curriculum guides; collaborative online projects; email directories; links to other teachers, schools, and governmental organizations; online classes; tutorials; and news about conferences. For example, the United Kingdom's National Grid for Learning (NGfL) "is both an architecture (or structure) of educationally valuable content on the Internet, and a programme for developing the means to access that content in schools, libraries, colleges, universities, workplaces, homes and elsewhere" (ICT in Education News, 1998). Schoolnet are being developed worldwide. European Schoolnet (http://www.eun.org/index. html), a project of the European Union, offers teachers access to a wealth of information about ICT use in education.

Schoolnets now exist in Canada (http: //www.schoolnet.ca/home/e/), France (http://www. educnet.education.fr/), Ireland (http://www.scoilnet.ie), Japan (http://www.schoolnet.or.jp/schoolnet/index-e.html), South Africa (http://www.gp.school.za /gsnsite.htm), Thailand (http://www.school.net.th), and other countries. The Canadian government has recently signed an agreement with the China State Education Commission and a Sino-Canadian joint business venture to establish a SinoCanada SchoolNet that will develop online Chinese-Canadian educational programs and 28 resources. This project will deliver services to students and teachers in both countries through a virtual campus (Zhu and Prescott, 1998). Locally Produced Content One of the advantages of new ICTs is that it empowers users to not only consume information, but also produce it.

With a computer, printer, and desktop publishing software, any local educational group can produce high quality printed materials. With an Internet connection and website, any educational organization can "publish" content derived from local knowledge and experiences. For example, eighth grade students in the United States at Dakota Meadows Middle School in North Mankato, Minnesota, have written short, twominute mysteries posting them on the World Wide Web and challenging other students to "Use your wits and detective skills to solve these cases." Over 20,000 people have visited the students' website (http://www.isd77.k12.mn.us/schools/dakota /mystery/contents.html). These same students have collected oral histories from members of the Mankato community about their experiences during World War II and made them available on the web (http://www.isd77.k12.mn.us/schools/ dakota/war/worldwar.html).

In another example, the Summer Institute of Linguistics (SIL) has helped set-up Literacy and Awareness Publication (LAMP) centers in each of the 20 provinces of Papua New Guinea to promote literacy in approximately 850 local languages. Few, if any, literacy materials exist in the majority of these languages, and over 55 per cent of the population aged over 10 is functionally illiterate. At these centers, literacy texts are produced covering a wide variety of subjects including healthcare, hygiene and preservation of the environment that can be shared between the centers. The computers, scanners, digital duplicators might be new technology, but the materials produced on this equipment are in local languages based on local customs and culture for local audiences (UNESCO/UNICEF, 1997b).

Content Standards Although many tools exist to help teachers and students locate information (cf.

Alexia.lis.uiuc.edu/lrl/links/search.html), At present, a lack of commonly held technical standards inhibits sharing educational resources across institutions and between a wide range of technical environments. This presents a significant obstacle to realizing the educational potential of ICT. At the moment, finding specific educational materials on the World Wide Web can be likened to a difficult and cumbersome scavenger hunt, often resulting in wasted time and unexpected results.

For example, a teacher searching the Web using a popular search engine, Alta Vista (http://www.altavista.com), for educational materials on "Southeast Asia" would find over 77,000 related webpages including information about books, travel agencies, journals, music, colleges, personal travelogues, pictures, satellite images, maps, newspaper articles, and so forth. On the other hand, if the teacher had entered "Asia, Southeast", the search would return over 800,000 webpages! Faced with such a hodgepodge of information, a teacher or student is hard-pressed to locate specific information or materials of use within the curriculum at a particular grade level. The results of such indiscriminate searches also raise the issue of the validity and reliability of the 29 information. Once found, because of varying technical standards, materials created with one ICT-based learning system may not be usable in a different environment. Several efforts to bring order to the chaos of the Internet and World Wide Web are underway.

The European Commission has initiated a Memorandum of Understanding: Multimedia Access to Education and Training in Europe to this end. As of December 1998, over 160 educational organizations, government agencies, and commercial companies have signed the MoU. The MoU is intended to bring together: … key players to identify key common issues to the further deployment of ICT based learning services and the provision of multimedia access to education and training in Europe … there is a great need for widely accessible and re-usable digital content that would either be delivered over telecommunications networks, or stored locally. For such content to be useful, it would need to conform to certain standards, both pre- and post-development taking into account the multilingual, multicultural European learning environments, the diversity of curricula in the different European education and training programmes, and special needs such as those of the disabled and elderly.

(European Commission, 1998) By the creation of technical standards, projects like the Dublin Core Metadata

Initiative (purl.oclc.org/dc) and the Instructional Management Systems (IMS) project (http://www.imsproject.org) may “help transform the end-user experience of the Web from the unstructured tangle it is today into something more like a digital library or virtual learning centre” (Sithers, 1998). If international agreement can be reached on an acceptable set of technical standards, educational materials developers will be able to embed in electronic materials information such as subject matter, grade level, educational objectives, and pedagogical approach. Teachers and students will then be able to search for educational materials with common descriptors and be assured that the materials, once found, will be compatible with local ICT applications. Teacher Education and Training To create ICT-enabled teaching and learning environments, it is also necessary to provide ICT training for teachers. As noted by Guskin (1996), “The changes being asked of faculty members in restructuring their work lives will be extraordinary and will require them to function in ways they never conceived of and for which they were not trained.” In some countries, for example Great Britain, it is now required to have training in ICT-use to earn a teaching credential (Teacher Training Agency, 1998). Beyond preparative training, as educational applications of ICT continue to evolve, refresher training for experienced teachers will be necessary.

In one possible framework for organizing ICT training for teachers, McDougall and Squires (1997) identify five foci: (1) skills with particular applications, (2) integration into existing curricula, (3) IT related changes in curricula, (4) changes in teacher role, and (5) underpinning theories of education. The authors note that most ICT teacher training mistakenly focuses entirely on the first issue. 30 Furthermore, it may not be sufficient to simply provide training for teachers. For instance, Murphy and Gunter and others (cf. Sharp, 1998) advocate that ICT training be extended to educational administrators: Lack of teacher technology training has been the failure of most schools trying to grasp technology and harness the power that technology can bring to the classroom. However, successful technology training can be accomplished only through effective administrative leadership … These leaders must be knowledgeable in the use of technology and must show support by providing access to the equipment and materials necessary for successful integration. (Murphy and Gunter, 1997, p. 136; 138)

But, even more vital than ICT training for teachers and administrators, there is a continuing need to educate qualified teachers to staff schools. ICT is being used in a wide variety of ways to support teacher education as well and teacher training in ICT use. Email, websites, desktop videoconferencing, and other technologies and applications are all playing a role in such efforts. Teacher Education Preservice teacher education refers to the formal preparation of individuals to enter the classroom as qualified teachers. Inservice teacher education refers to on-going professional development programs offered to teachers once they have entered the profession. Perraton and Potashnik (1997), in a review of ICT use in teacher education, note that while most teachers working in schools worldwide have received some preparation, not all have received adequate preparation. In fact, many have received none at all. In India in 1996, for example, there were about 240,000 teachers who were not fully qualified. There also are severe teacher shortages in many countries, the problem being especially severe in South Asia and Africa (p. 4).

Even in developed countries where there are sufficient numbers of teachers, as in the U.S.A., many are unqualified or underqualified to teach specialized subjects like mathematics and science (cf. National Science Foundation, 1998). ICT is being used in a wide variety of ways to support both preservice and inservice teacher education. In Africa, UNESCO is developing a large distance education project to help eight countries train teachers and principals unreached by traditional training. The project, to be launched in 1999, is expected to train half of the teaching staff in five selected countries (UNESCO Education News, 1998). Also in Africa, education ministers from six Southern African Commonwealth countries have signed an accord to co-develop distance education programs with a priority given to the in-service training or teachers in science, mathematics, and technology (Commonwealth of Learning, 1998). In Australia, the Faculty of Education at the University of Wollongong is linking teachers and postgraduate students directly to lecturers through email networks and provides online support to teachers in schools (Hedberg & Harper, 1996).

TeacherNet UK (http://www.teachernetuk.org.uk), an independent organization, offers teachers the opportunity to develop an online profile of their interests, needs, and prior achievements, and then matches the individual participants accredited professional development programs. TeacherNet

UK also enables peer support and mentoring through email and web-based discussion groups. In Iceland, the University College of Education offers a Bachelor of 31 Education (BEd) degree via the Icelandic Education Network (http://www.ismennt.is). In Denmark, teacher education is being conducted using ICT including computer-mediated conferencing (CMC) supplemented by satellite-based teleconferencing, multimedia and standard computer-based training (Ingesman, 1997). And, in a final example of how ICT is being used to support teacher education, the TRENDS (Training Educators through Networks and Distributed Systems) Project (http://www.lrf.gr/english/trends/trendshome.html), a collaborative effort of the seven European Union countries, is developing an in-service, school-based teachers training system based on multimedia and network technologies. Teacher Training As noted in a Finnish government report of a technology assessment project, “how computers are used in education depends on the pedagogical competence and technical skills of the teaching staff who must know how to exploit these modern technologies in pedagogically meaningful ways” (Finnish National Fund for Research and Development, 1998).

Regional, national, and local plans for ICT in education typically include provisions for teacher training (cf. World Bank, 1998). ICT training for teachers has at least two aspects – technical training and preparation to integrate ICT use into the curricula. First, teachers need technical training to learn how to use and maintain ICT equipment and software. Such technical training is being offered to teachers in a wide variety of ways. Preservice university-based courses, inservice workshops, commercial training programs, and other opportunities abound, many of which make use of ICT to deliver instruction (cf. "New Technology Training Method Brings Ga. Educators Out Of The Dark, 1997; McKenzie, 1998). Second, as "integration of technologies into curricula requires changes of huge magnitude" (Foa, Schwab, and Johnson, 1998, p. 1), training in how to integrate ICT-use into the curriculum is necessary. Such instruction should including effective teaching methods with ICT and the use of discipline specific applications: Most faculty members say they don't have the time or skills to experiment with the World Wide Web, let alone try complicated courseware, streaming video, or on-line message boards. They need sophisticated guidance, which most computer-help desks and student assistants can't provide. And they need more than a computing center's basic training in how to use Windows or word-processing software. (Guernsey, 1998, p. A35)

Many promising approaches are being developed to provide such support for faculty. In an expensive but effective approach, several universities have established “expert partners” programs. As reported by Guernsey, “people who fill the jobs have one thing in common: a hybrid expertise that blends academic computing with college teaching” (1998, p. A35). Staff who are both qualified academics within a discipline, and who have expertise using ICT for instruction, are hired “to provide faculty on-site, intradepartmental consulting and support in information and instructional technology for academic purposes to foster their awareness and use of technological resources, both within and without the University” (rits.stanford.edu/atss/atp/index.html). 32 Training methodologies vary, but “training of trainers” models are common and, in most instances, may be more cost-effective than on-site, small group or individual ICT training. In such programs, “teacher-leaders” are selected by a variety of criteria, usually including prior experience with ICT in education, staff development expertise, and commitment to the program by school and district administration.

These individuals receive intensive training courses to master technical details and approaches to integrating ICT into the curricula. Once trained, they return to their educational institutions and provide ICT training and support for their peers. Such programs may also include on-going, long-term support for the trainers including site visits, computer-based conferences, and email mentoring. In large geographical areas, the responsibility for such training and on-going support may be delegated to regional ICT consortia, coordinated by a central administrative body. For example, the U.S. Department of Education has funded six Regional Technology in Education Consortia "to help states, local educational agencies, teachers, school library and media personnel, administrators, and other education entities successfully integrate technologies into kindergarten through 12th grade (K-12) classrooms, library media centers, and other educational settings, including adult literacy centers" (http://www.rtec.org). 4 In an innovative and less inexpensive approach, students are being enlisted to provide ICT support and training for teachers. At Wake Forest University in the United States, incoming freshmen are hired and trained to work as Student Technology AdvisoRS (STARS). STARS are assigned faculty members to help implement ICT-based projects (http://www.wfu.edu /Computer-information/STARS/ index1.html). Also in the U.S., a consortium of educational associations has launched a national grassroots project to train public school teachers to use computers and the Internet.

The project, 21st Century Teachers (http://www.21ct.org) hopes to recruit 100,000 educators this year to train their peers. In the United Kingdom, the ICT Training Initiative of the Teacher Training Agency (TTA) (http://www.teach-tta.gov.uk) offers a combination of technical and discipline-specific applications training. The TTA, working with other educational organizations and a commercial company, will produce a package – including CD-ROM, video and paper-based materials – to help teachers identify their specific training and development needs in the use of ICT in teaching their subjects. Starting in April 1999, training – some of it Internet-based – will be offered to enable existing teachers to acquire the ICT knowledge, understanding, and skills which will be expected of all newly qualified teachers entering the profession from 1999. In Australia, the Connecting Teachers to the Future project is providing teachers with training and a laptop computer, modem, and an Internet account "to empower teachers with personal skills in the use of information and communications technologies and to help them enhance the curriculum they develop for their students" (Gray & Buchanan, 1998).

Technical Support Although standard service agreements, purchased separately or included in the purchase of ICT equipment and software, typically cover regular maintenance and repair costs, and may even include email or telephone support, such arrangements may fall short of what is necessary in educational settings. Without adequate technical support, schools have experienced "large workloads for existing staff, maintenance backlogs, and reduced computer use because computers were out of service" (U.S. Government Accounting Office, 1998). The provision of on-site, timely technical support may be critical to the success of an ICT-based educational program: There appears to be general agreement among observers that, at least in the foreseeable future, schools that are attempting to implement technology on a wide scale need to have on-site technical assistance. Although some sites have attempted to make do with help from a knowledgeable teacher volunteer or with part-time services from a district technology coordinator, such arrangements are often unsatisfactory. Like all of us, teachers trying to use technology in their classrooms want technical help on demand. Controlling a classroom full of students in the midst of some activity that requires technology when the system goes down requires flexibility and skill.

If technical problems arise frequently and teachers have to wait hours, days, or weeks to get them resolved, they will abandon their efforts to incorporate technology. (Fulton, 1998b) In universities, such support may take the form of technical staff assigned to a "computer center," "media center," or "distance learning center." In schools, knowledgeable peers, students, volunteers, specialized computer lab teachers are providing such support, and, less frequently, trained technical staff located either within the school or district office. In an example of students' expertise being utilized, members of the American Technology Honor Society (ATHS) (nassp.org/aths /aths_frm.htm) provide ICT support and training for faculty members at their schools. In an example of how volunteers may provide such support, TECH CORP (http://www.ustc.org), a U.S.-based, non-profit organization, draws volunteers from the local communities who conduct teacher training seminars, serve as technology mentors to students and teachers, repair and install computers, participate in technology planning, and assist with the integration of technology into the curriculum. SIGNIFICANT ISSUES National Planning ICT implementation in education is a difficult, expensive, and complex undertaking that must consider a host of issues including infrastructure, curricula changes, teacher training, technical support, and so on.

Such an undertaking, especially on a national level, requires careful planning. Numerous developed and developing countries have implemented national strategies and plans for education that include ICT (cf. France [http://www.educnet.education.fr/pages/01/m01.htm]; Portugal [http://www.dapp.minedu.pt/nonio/ ingles/docubase1i.htm]). 34 However, others have not: “Many governments stand at the threshold of the twenty-first century without clearly-defined plans and strategies about the use of educational technology – but they are making major new investments anyway” (World Bank, 1998, p. 31). A lack of careful planning may result in wasted resources or ineffective implementations. Drawing lessons from programs in Latin America, the Caribbean, and elsewhere about the effective incorporation of ICT in education, the Report identifies generic issues for planners to consider when developing national ICT in education strategies. These are broadly grouped into three categories: educational policy and goals-setting, teaching and learning, and institutional development and capacity building. In the Report, sound planning that sets priorities tied to existing and projected efforts for educational improvement is seen as critically important.

The report also itemizes several successful strategies implemented to varying degrees by these countries including:

(1) developing a national or regional plan for county-wide deployment of technologies,

(2) implementing experimental projects to gain experience for country-wide deployment,

(3) undertaking small-scale demonstration projects,

(4) using technology to address educational equity issues (see section below on "Equity of Access"),

(5) using broadcast technologies, including computer networks, to reach learners in remote areas,

(6) investing in preparing students and teachers for technology-based jobs,

(7) creating schools using ICT as their core educational delivery system

Claeys, Lowych, and Van der Perre (1997), in an article based on interviews with a sample of 65 experts from across

Europe about introducing ICT in education, summarize the respondents view of the role of government as developing a clear vision on reforming the educational system through ICT, enacting adequate funding measures, and establishing partnerships with education and industry for the development of educational software.

In addition: … interviewees expect:

(1) the development of a special cell in the department of education to support the introduction of ICT in education,

(2) the development of incentives/projects,

(3) the development of an advisory council to help the government promoting the introduction of ICT in education and,

(2) the re-creation of the curriculum, in which information technology is embedded and an equivalent adaptation of the rules for examination.

Osin (1998), summarizing the experiences of projects meant to introduce computers into the educational systems of developing countries, offers prudent advice. He warns against beginning a project by purchasing computers, which often results in “a waste of money that could be put to better use” . Instead, he advocates an eight step planning process beginning with gathering together the necessary expertise in an Advisory Committee that will define and implement a plan beginning with the careful execution of pilot projects.

Osin also recommends training a cadre of instructors for teacher training, introducing computers into teachers colleges, and conducting both formative and summative evaluations of the pilot projects before attempting a large-scale ICT implementation. Beyond planning, national governments have a role to play helping remove political and economic roadblocks that prevent sharing educational resources between countries. McIsacc & Blocher, (1998), in a discussion of distance education, advocate: “Courses offered globally should encourage broad international participation and have sliding scale tuition policies.

Sharing in developing educational materials and courses saves the 35 duplication of time and effort and conserves valuable national resources”. Potashnik and Capper (1998), note: Employers and universities are now drawing both staff members and students from all corners of the globe. Consequently, they face new challenges in evaluating course work done at, and degrees earned from, unknown institutions in other countries. While accreditation has typically been controlled by individual countries, the globalization of distance education has created a whole new challenge in accreditation and certification of learning.

Potashnik and Capper point to the Global Alliance for Transnational Education (GATE) (http://www.edugate.org), an international alliance of higher education, government, and business, as one effort "to carry out the formidable task of creating a global certification and review process for education delivered across borders" . Government intervention may also help assure affordable ICT access for education. For example, telecommunications rates may be regulated to assure economical ICT access to educational institutions.

In late 1996, the U.S. Congress enacted the Telecommunications Act of 1996 (http://www.technologylaw.com/techlaw/act_index.html). The universal service section of the law, Section 254, will help U.S. schools and libraries obtain access to telecommunications services and technologies at discounted rates. And tax incentives, such as the 21st Century Classrooms Act for Private Technology Investment (P.L. 105-34, Title II B, Sec. 224) (hillsource.house.gov/IssueFocus/SpecialProjects/ALearner/ ALMain/tech.pdf), enacted by the U.S. Congress in 1997, are a potent means to encourage corporate ICT equipment donations to educational institutions. The Act allows companies to deduct the full price of a computer donated to a school within two years of purchase. However, because ICTs are rapidly evolving, national educational policies on ICT, once put in place, "have to be regularly updated if they are to respond adequately to the challenge of effectively exploiting these constant changes to the technologies and their applications" (Byron & Gagliardi, 1996).

Intellectual Property Intellectual property refers to original or novel creations of the human mind. Intellectual property rights give the creator exclusive right to use such creations for a specified period of time. These creations may include literary works, industrial designs, musical compositions and arrangements, paintings, trade secrets, sculptures, computer programs, performances, inventions, and so forth. Copyright, trademarks, and patents are legal methods to protect such rights. The creation, maintenance, protection and transfer of intellectual property assets are increasingly important in today's global economy.

The availability of ICT and the ease with which the fruits of human creativity may be duplicated, incorporated into multimedia products, and transmitted worldwide has led to increasing efforts to govern such use. In an era when every student and teacher is a potential publisher of multimedia materials that incorporate the works of others, information and training about the ethical use of intellectual property should be an important component of efforts to bring ICT use into the classroom.

Without international laws protecting intellectual property, and mechanisms by which to “meter” charges for its use, efforts to share resources globally will be inhibited. For example, the University of Pittsburgh in the USA, in cooperation with six major Chinese research libraries, has established the Gateway Service Center of Chinese Academic Journal Publications. The web-based system enables researchers to request articles from more than 10,000 Chinese academic journals housed in libraries throughout China, Hong Kong, and Taiwan while scholars from those countries have direct access to articles from most American journals. However, once requested electronically, the articles must still be printed and mailed because of publishers fears that copies will be distributed illegally over the Internet (Guernsey, 1998).

In universities, copyright concerns may be inhibiting the creation and use of ICT-based instructional materials. For example, increasing use of ICT has led to a re-examination of the question of ownership of materials produced by faculty: The ownership of intellectual property is among the most widely debated issues on university campuses today, and those debates go far beyond the distance learning issue itself. Typically, in settings other than universities, it is well settled that the material created by employees within the scope of their employment is owned by the employer. However, the unique mission of the university, academic tradition, and the essential principles of academic freedom have led faculty to claim that they own the material they create.

Historically, many university administrations have asserted institutional ownership, but then allowed, or not challenged, the faculty position with regard to copyrights, at least in part because both the financial "cost" and the value of most copyrightable creations were usually insignificant when compared with the cost and value of patentable inventions. But as the potential value of copyrighted material escalates, particularly with the advent of multimedia software, and as financial resources diminish, many universities are revisiting who owns the intellectual property created by faculty. (American Association of University Professors, 1997)

International efforts are underway to develop global standards and agreements that will protect intellectual property rights while developing methods to allow access to, and sharing of, intellectual property. For example, The United Nations' World Intellectual Property Organization (WIPO), an intergovernmental organization with 171 participating countries (http://www.wipo.org): … is promoting the protection of intellectual property by the development and application of international norms and standards.

The Organization currently administers 11 treaties establishing such norms and standards - 5 dealing with industrial property and 6 dealing with copyright, that set out internationally agreed rights and common standards for their protection, that the States which sign them agree to apply within their own territories. (http://www.wipo.org/eng/infbroch/infbro98.htm) ICT itself is being used to provide assistance and information to educators and others interested in intellectual property laws. WIPO has just begun work on a global information network using the Internet that will facilitate the storage and rapid exchange of intellectual property information between all interested parties in governments and the private sector in 37 member States. LexMunid (http://www.hg.org/guides.html), a global association of 152 independent law firms, offers a website directory with links to hundreds of legal guides about countries around the world, most of which contain information concerning intellectual property laws.

Other organizations, such as the U.S. Franklin Pierce Law Center (http://www.fplc.edu), Ruslaw in Russia (http://www.ruslaw.ru/ intprop1.htm), and the Australian Copyright Council (http://www.copyright.org.au), offer websites with information about national laws governing intellectual property rights. Equity of Access Equity of access, put simply, means that all people, whether rich or poor, living in a developed or developing country, male or female, have access to the benefits of ICT-use. While this ideal is widely supported, it is a long way from realized. Haves and Have-Nots Access to and use of ICT is still predominately a phenomenon in developed, wealthier countries. This disparity leads to concerns that ICT will broaden and deepen the economic, educational, social, and political gaps that divide the developing from the developed nations, and the poor from the rich: … while all countries in the world have been affected to a greater or lesser extent be the influence of ICTs in various domains of daily life, it has been and continues to be a very uneven "revolution" with its catalytic effects on development in the rich industrialized countries of the North, serving to widen the disparities existing between them and the South …

Within such a context, there is a real risk that technology will become just another means for widening the gap between economic "haves" and "have-nots", that it will develop into another way of imposing outside models on others, and that global culture, with its tantalizing images of potential wealth and symbolism will override and devalue local knowledge systems … As with most other areas of development, there is a huge gap between the North and the South in the exploitation of these technologies in education. (Byron and Gagliardi, 1996)

The World Development Report 1998/99 (World Bank, 1998), notes, "Poor countries – and poor people – differ from rich ones not only because they have less capital, but because they have less knowledge" (p. 1). This inequity has been recognized by international agencies such as the United Nations and World Bank, and governments of the developed countries. As was noted earlier, UNESCO, through the Learning Without Frontiers (LWF) project and other programs, is helping organize and finance pilot ICT in education projects in developing countries. National governments in developed countries, too, are taking measures to assist in the creation of ICT infrastructure in developing countries.

For example, the Clinton administration in the United States is pushing for funding to help developing countries link to the Internet for commercial and educational purposes (Miller, 1998). But huge inequities exist that will be difficult to overcome. If inequities in access to ICTs in developing countries can be overcome, it may enable their citizens to leapfrog over economic and educational barriers: … developing countries need not reinvent the wheel – or the computer, or treatment for malaria. Rather than re-create existing knowledge, poor countries have the option of acquiring and adapting much knowledge already available in the richer countries. With communications costs plummeting, transferring knowledge is cheaper than ever. … Expanding telecommunications holds the promise to improve every developing country's capacity to absorb knowledge, for example by providing opportunities high-quality, low-cost adult learning. (World Bank, 1998, p. 2; 10)

Expanding telecommunications capability also provides an avenue to reach distant markets with locally produced products while at the same time educating others about local cultures. The Catdang Village Project in Vietnam is using ICT to reach a worldwide audience with information about local cultures while exploiting economic opportunities. The web-based project, selling locally produced lacquered bamboo baskets, is aimed at "providing sustainable regenerative income for village artisans and their families" (http://www.itc.org/catdang_kr.htm). While economically oriented, the website contains cultural information and images of Catdang; a small village located over a hundred miles south of Hanoi. Other inequities in ICT access exist. The poor are less likely to have access to ICT, in or out of school. As Byron & Gagliardi, (1996) found, "Even in the developed world, access to the benefits of these technologies has by no means been equally available throughout all sectors of the population, with certain sections of society remaining deprived of many of the advantages offered by ICTs" (p.2). And as a Benton Foundation report (1998) notes, instead of offering new economic opportunities to the poor, ICT may actually worsen their plight: … even as digital technologies are bringing an exciting array of new opportunities to many Americans, they actually are aggravating the poverty and isolation that plague some rural areas and inner cities.

Advances in telecommunications are speeding the exodus of good jobs from urban areas to the suburbs, leaving inner cities and rural areas more isolated than ever from the kinds of jobs, educational opportunities, quality health-care services, and technological tools that they need to be able to contribute to the overall economy.

This technology gap has ominous implications not just for the low-income communities that are directly affected, but for the entire society. (p. iv) This same report found that schools in high-income areas were much more likely to have lower pupil–computer ratios and Internet access, a finding confirmed by Heaviside, Riggins, and Farris (1997). Throughout the developing world, the situation is much worse. Access to even basic communications technologies is limited to a few. In South Asia and Sub Saharan Africa, there are about 1.5 telephone lines per 100 people compared to 64 per hundred in the United States (World Bank, 1998, p. 9). In conclusion, when considering ICT, “threat and opportunity are opposite sides of the same coin” (World Bank, 1998, p. 14). ICT has the potential to greatly enhance the information base, knowledge, and educational opportunities of the poor and of developing countries. However, such benefits will depend upon whether there is equitable access to ICT. If not, ICT may increase the gap between the haves and have-nots of the world. 39 Gender According to UNICEF, over 130 million children of school age in the developing world are growing up without access to basic education, of whom nearly two of every three are female (UNICEF, 1998, p. 7). If lucky or privileged enough to attend school, a number of studies have shown females are far less likely to enroll in science, mathematics, computer science and engineering courses (cf. ethics.cwru.edu/ecsel/abstracts/ women.html; http://www.becta.org.uk/info-sheets/gender.html; http://www.nsf.gov/sbe/srs/ seind96/ ch1_cont.htm). In the United States, Birdsell, Muzzio, Krane, and Cottreau (1998) report increasing use of the World Wide Web by women: In the winter 1997-98 surveys, 44% of the Web users were women, up from 21% in September 1995.

As a portion of the overall US population, 3% of adult women in the September1995 survey said they logged onto the Web compared to 12% of men. Research now shows that 26% of all American women use the Web, as do 35% of men. (p. 1) However, U.S. women, too, choose ICT-related careers less frequently, and are more likely to change career fields: “Women are leaving or avoiding computer careers in droves, citing discrimination by male co-workers, few role models, family-unfriendly work environments and a general sense that the field is irrelevant to their interests … The most immediate effect is to worsen the nation's shortage of high-tech workers" (Piller, 1998). In America's New Deficit: The Shortage of Information Technology Works, the U.S. Department of Commerce's Office of Technology Policy reported: Women--who comprise 51 percent of the population and earn more than half of all bachelor-level degrees awarded--earn about one-quarter of the bachelor-level computer and information sciences degrees awarded by U. S. academic institutions. More disturbing is the trend line: the share of all computer science degrees awarded to women in the United States has fallen steadily from a peak of 35.8 percent in 1984, to only 27.5 percent in 1994--the lowest level since 1979. (1997, p. 24) As ICT becomes more commonplace in educational settings, gender differences in access and use of such tools and resources in schools are also emerging.

Based on research synthesizing over 1,000 studies, the American Association of University Women (AAUW) Educational Foundation recently reported, "Girls have narrowed some significant gender gaps, but technology is now the new 'boys' club' in our nation's public schools. While boys program and problem solve with computers, girls use computers for word processing, the 1990s version of typing" (AAUW Education Foundation, 1998). One means being explored of overcoming gender-based inequity in the study and use of ICT is to develop classes specially designed for female students (cf. Zehr, 1998). Another is the use of ICT to support mentoring. For the past two years, for example, Dartmouth College has offered E-Mentoring (http://www.dartmouth. edu/~wisp/ electronic_mentoring.html), a program that links female students with professionals in science, engineering, and mathematics by email to encourage them to enter and stay in traditional male professions. This effort has led to the establishment of Mentor Net (http://www.mentornet.net), a national 40 program that plans to provide mentors for 5,000 female students in traditional male disciplines over the next five years (Haworth, 1998). ICT is also being used both to provide information about gender issues to teachers (cf. http://www.wri-edu.org/equity/gender.html), and to encourage women's use of information and communications technologies.

For example, the Women's Net (womensnet.org.za) project in South Africa offers a variety of information on women's issues and is planning to offer an Internet training program for women in the near future. The Ada Project (TAP) and its TAP Junior offshoot at Yale University in the United States (http://www.cs.yale.edu/HTML/YALE/CS/HyPlans/tap/tap.html), serves as a clearinghouse for information and resources relating to women in computing. The Center for Women and Information Technology at the University of Maryland Baltimore County (UMBC) (http://www.umbc.edu/cwit) is dedicated to addressing the technology gender gap. Its website includes curricular resources, news articles on gender and technology, and links to sites focusing on women, girls, and information technology. Cultural Imperialism Concerns about cultural imperialism and the impact of ICT on local cultures and languages – given the dominance of the Internet by the developed, English-speaking countries – are growing: … the Internet is supposed to be an open ground on which expressions and even representations of different cultures can be acted out in diversity. However, this promised diversity on the global network is set back and held in suspicion, for many, by the cultural imperialism represented by the West in general and U.S. culture in particular. Rather than empowering local and the marginal cultures to speak out for themselves, globalization appears to be synonymous with standardization and normalization of one privileged, globalized local culture over others. (Lee, 1998) Such concerns are especially acute as they relate to the education of young people: One of the major concerns voiced [at the 1996 UNESCO Second International Congress on Education and Informatics in Moscow] was that unless minority groups and non-English-speaking countries consciously start providing information on the Internet, the western world and the English language will continue to dominate the system.

The UNESCO Congress made it clear that, while the Internet enables countries of the North to share educational materials and research with the Third World and permits developing countries to make their own materials available online, it also reinforces a likelihood of "cultural imperialism." (Khvilon & Patru, 1997) Language is frequently the focus of such fears. According to some estimates, 90% of all information posted on the Internet is in English (Herschlag, 1996). Surprisingly, however, there is near parity of the number of Internet users who are native English speakers (91 million) and non-native English speakers (71.3 million). But this may soon change. The fastest growing group, in terms of language, are those who access the Internet in languages other than English.

When ranked by native language groups, the largest groups on the Internet are the Spanish-speaking (14.2 million), the German-speaking (13.7 million), and native Japanese-speakers (12.3 million). French-speaking Internet users, the fifth largest 41 group, account for six million while Mandarin (Chinese) speakers account for 4.1 million. (Euro-Marketing Associates, 1998). Whether the changing language demographics on the Internet will result in English becoming a common language for ICT-enabled discourse, or will result in a "tower of ICT-enabled babble" is an open question. Language translation software may offer some solutions to this problem (cf. http://www.unl.ias.unu.edu/eng/unlhp-e.html), but such technologies are far from mature. However, as Everhart (1998) noted: "we should not lose sight of the potential of these applications for enhancing global understanding. … Dance, music, collected memories, and shared imaginings can provide a common global language."

Paradoxically, despite fears of cultural imperialism on the Internet, use of ICT is also seen as a means to protect and project cultural, religious, and other differences: There is an important counter-effect or internal contradiction in our global, Net based information society: simultaneously with the rise of global networked society there is an increase in national, ethnic, and religious identity politics and the resistances to globalization inherent in these movements. Many of the identity groups represent themselves as explicit points of resistance to a global system of any kind while simultaneously using the tools of globalization (Net communications, Web presence, satellite communications).

(Irvine, 1998) ICT is also enhancing the ability of people from different cultures to interact with and create cultural materials. For example, the Cassandra Project (http://www.nyu.edu/pages/ngc/ ipg/cassandra) stages events on the Internet with performers from around the globe that incorporate dance, poetry, music, video, and drama using videoconferencing and audio streaming. Audiences worldwide are able to watch and participate.

The Academia Sinica in Taiwan has developed a full-text searchable database (http://www.ihp.sinica.edu.tw/database/ index.htm) of Chinese classics, including the 25 Books of History and other philosophical and literary texts, making these cultural products available to a worldwide audience. Whether the Internet will create a "Global Village" in which all participants' cultures and languages are equally valued, or foster an "invasion" by which diverse cultures and languages will be electronically subjugated, is an open question. Pornography, Violence, and Censorship Although connectivity, including access to remote resources, is a major beneficial feature distinguishing newer ICTs from old, such access has negative aspects. Whether – and to what extent – the free exchange of information will take place using ICT is being widely debated, with the transborder nature of ICT adding new, complex dimensions to such discussions (UNESCO, 1997, Part 3).

Concerns about pornography, violence, and crime on the Internet are widespread (cf. http://www2.echo.lu/legal/en/internet/communic.html), and Internet political activism is also raising alarm in some countries (cf. http://www.savetibet.org). Anti-censorship (cf. http://www.eff.org) and pro-censorship (cf. http://www.enough.org) organizations are carrying the debate to a worldwide audience through ICT.

Human Rights Watch (http://www.hrw.org), a non-profit group founded " to end a broad range of abuses including … restrictions on the freedom of expression," recently reported that in many countries such concerns have given rise to efforts to impose censorship and restrict the free exchange of information on the Internet: … in a half-dozen countries, Internet access providers (including public libraries) were implementing filtering technologies and other voluntary measures to make prior censorship of on-line communications a reality. The trend is towards extending these technologies more broadly, with global implications for free expression. On-line content providers may soon be forced to start rating their content; those failing to rate their content may find their material blocked from public access.

As local rating criteria are used to define ratings, the danger is that these restrictive criteria will limit the diversity of expression on the Internet, where content is as diverse as human thought. (http://www.hrw.org/hrw/worldreport99/ special/ internet.html) This debate is particularly serious when framed in the context of education. Given the ease with which students may access inappropriate materials using ICTs, critical questions about ICT-use in schools are being raised by religious organizations, government officials, administrators, teachers, and parents. A government official in Hong Kong recently warned, “While the Internet is a powerful source of information, it can also pollute young minds, so teachers should give guidance on the moral hazards in today's computer age" (Moy, 1998).

In Argentina, religious organizations called into question school access to the Internet when material promoting the use of condoms was put on the Web by an AIDS foundation (Kolesnicov & Kolesnicov, 1998). ICT manufacturers are introducing ways of overcoming the problem of school children being able to access content deemed inappropriate by local schools and parents. Such tools include "proxy servers" and "filtering" software. A proxy server is a computer on the school network on which educators can store pre-screened and approved information. Use of a proxy server limits student access to only those resources placed on the local server. "Filtering" software scans incoming information for specific words, phrases, or websites and blocks access to banned content (cf. http://www.schoolnet.co.uk/about/ ninaa.html; http://www.csm-usa.com/pr/981112.htm).

Beyond the questions raised by pornographic, violent, politically unsuitable, or criminal information on the Internet, another issue facing educators is the validity of the information available on the Internet. "While a wide realm of information is available on the Internet, it must be remembered that there is no monitoring agency and no restriction on posting false information for all to see" (Peace, 1998, p. 394). Students searching the Internet for information about the question of life in outer space are just as likely to find arguments based on religious believes (cf. http://www.creationscience.com/onlinebook/faq/ lgm.html), paranormal cults (cf. http://www.discribe.ca/ufo/contents.htm), as on scientific evidence (cf. ccf.arc.nasa.gov/dx/basket/pressrelease/97_75AR.html).

It appears unlikely that this situation can be resolved. As Peace recommends, "Care must be taken by the instructor that students are made well aware of this situation, and that policies are developed to deal with the inevitable dilemma raised by a student citing incorrect information, found legitimately on the Internet, in support of a flawed argument".

CONCLUSION

As we trust has been demonstrated in this chapter, the use of newer, digital ICTs – because of the ability to integrate multiple media, interactivity, flexibility of use, and connectivity – are inspiring remarkable transformations in education around the world. These transformations hold promise for the improvement of the lives of the rich and of the poor, whether living in developed and developing countries.

We have chosen to focus on existing, widespread uses of ICTs in education, but advances in wireless telecommunications, virtual reality, pervasive computing, artificial intelligence, speech recognition, and “next generation” networking technologies promise to remodel today’s educational applications as comprehensively as the computer revolutionized yesterday’s. If we can claim to have detected any “theme” in our overview of ICT in education worldwide, it is this – ICT is neutral, human choices will determine how ICT will be used and whether the revolution in information and communications technologies will benefit all humanity.

This is true at the micro-level, in the choices teachers make when deciding whether and how to use ICT in the classroom, to the macro-level, by the choices international, regional, and national governmental and non-governmental organizations (NGOs) make to support, or not, ICT access in formal and informal educational settings. Of course, we hope the information contained within this chapter (which will no doubt be out-of-date shortly after publication) can help individual decision-makers reach informed choices about ICT in education. But more than that, we hope the remarkable developments reported in this chapter have touched the imagination and helped inspire a sense of urgency to act to so that all children may benefit.

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OBJECTIVES OF ICT USE IN EDUCATION

E-learning, distance education, digital textbooks, virtual laboratories and other new words and concepts are getting in focus of researchers and educators worldwide. As time goes by new terms and ideas will join them and pioneers will embrace and explore them further. However, real benefit will be apparent when they leave the laboratories and experimental programs and spread throughout academic and educational community as a common practice. For a broad acceptance and deployment of ICT in educational process necessary technical infrastructure, legal framework, financial support and psycho-social climate need to be recognized, defined and established. In order to do that educational policy and decision makers should have clear understanding of the benefits and costs of ICT.

The leverage of ICT in education can be broadly separated in three areas: administrative, technical and other supportive functions for education; automation, assistance and support of learning and teaching and completely new teaching and learning methods, techniques and tools. This paper aims at identifying objectives, leaders, drivers and requirements of the ICT implementation in all three areas.

The 21st century is already the age of knowledge, the knowledge society and the educational age. The educational industry will be the industry of the 21st century. It is only natural that new technologies, ICT (Information and Communication Technology) above all, are in the focus of those who are contemplating the novelties in education. ICT has brought a range of new terms in the education like: e-learning, distance education, virtual classrooms, etc. While new terminology is being defined and redefined, hundreds of pioneers experiment with the usage of ICT in education. The strategists of education, politicians and decision makers on the national and international level are prophesying, proposing, planning and talking about major benefits from ICT implementation in education.

The Hopes The most important benefit from ICT in education it is hoped for is improved learning outcomes. It would provide necessary skilled workforce for the knowledge society while boosting cost/benefit ratio. No less important is hope to speed up learning process making it in average much faster than today. Democracy would get to its full potential by democratization of learning, lowering all sorts of boundaries between students and knowledge while bringing knowledge to all students and unlimit .

The Vision Fueled with these hopes and based on proliferating use of ICT in almost every aspect of modern life, almost universally shared vision is created. This vision believes that overall human knowledge (already mostly is, but certainly) soon will be fully digital and available to any student globally for whatever purpose. The world where a student is restricted to locally available teacher is the past and we see the world in which student and teacher are globally matched and paired for a specific learning activity based on desired outcome, psychology, timing, cost, and multiple other factors. It is envisioned that students will learn anytime when their need and ability meet, at the pace that best suites them.

Finally, it is clearly seen that education process will be freed from non-educational activities like: administration, support, organization, etc. They will be minimized, automated, reprogrammed, asynchronous and delegated.

The Reality While an army of researchers are seeking technical and organizational solutions, while pioneers all over the world already for more than a decade experiment “in vitro” implementing those solutions and while politicians talk and beehive as if they single handedly created the vision and bore solutions for it and as if the vision is already implemented and realized, the reality is quite different. ICT is still far from the mainstream of education. It is predominantly in hands of pioneers and early adopters, still on the margins of early majority. The furthest most “mainstream educators” came is to publish “digital photocopies” of their educational materials. They simply switched media leaving materials in the form of “paper age”. Even worse, e-learning is still mostly illegal.

Not that someone will be prosecuted for doing it, but in the sense that only minority of educational institutions recognize e-learning as their regular way of teaching and learning and even smaller number makes it their strategy and priority. The whole initiative is operating in an organizational vacuum in most educational institutions, globally. The expectations form ICT leverage are greatly exaggerated while not being properly planned for and without or with only symbolic financing. The key problem are missing and unassigned responsibilities in the envisioned change process.

The Forces Thus those visions are nothing more than dreams tending to become illusions. So, what can be done to change that situation? The first thing to look at are the forces to change. Without a change driver there won't be any change. The forces in any process come from the customer, internally and from the environment .

The ultimate customer of the educational industry is the one who uses skilled professionals: the industry. The industry is already demanding well educated highly skilled professionals. There is increased demand for customized education targeted at specific subset of knowledge or tailored for a specific project .

Another demand from industry is globally standardized certification of knowledge and skills. Internal change forces are students and teachers. Because of the industry demands, students need customized education, now and fast and they do not want to waste time on any kind of overhead: administrative, organizational or any other. Teachers want to reach every student globally available in order to maximize the gain from their investment in designing educational materials, tools and processes. They too want to reduce overhead in order to boost their own productivity. The globalization process creates pressure from the environment creating competition where there wasn't any and bringing it from sources unknown till now.

For example, globally available virtual labs and remote labs compete with physical facilities at local school. Competitors are no longer only other local or national schools not even well established and recognized schools from the world. Competition today comes from countries and institutions one barely heard of or even from industrial education facilities whose educational certificates are globally recognized and demanded (Cisco, Microsoft, LPI, ECDL, …). Finally, the process of decoupling teaching from certification (ECDL, LPI, …) is a force in itself that will irreversibly change the landscape of traditional educational institution we all are familiar with. 6. The Aim Leveraging the forces available and bearing in mind the vision, a realistic aim should be agreed upon.

An aim on which change agents, implementers and all other players could keep an eye while embarking on this exciting journey of fundamentally changing the activity which makes humans essentially different from all other species: learning .

This aim could be surprisingly simple. It is to move ICT from labs, experimental institutions and pilot projects to every days practice in a broad number of activities in majority of schools. . The Way Using this aim as an orientation point, a way towards it needs to be designed. The way is a stepwise process to be followed both globally and in each segment of the way or specific activity.

It needs to:

• define objectives,

• for each objective identify: change drivers, players, resources, outcomes, leaders,

• set the infrastructure,

• plan, • publicize.

The first step is to define objectives. Objectives are clearly defined realistic goals to be accomplished. In the next step, for each objective change drivers, players, available and needed resources as well as measurable expected outcomes need to be identified. Leaders are those who initiate and sustain the change process. The third step calls for setting the infrastructure. It encompasses everything that will be used in the change process or that will support it: strategies, materials, equipment, money, time, people, education, consultants, … With infrastructure set, a change plan consisting of sets of well documented procedures needs to be designed. Finally, the players in the change process need to become informed and familiarized with all this through extensive and continuous process of publicizing.

The Objectives This paper’s scope is to propose one possible set of objectives that could realize above defined aim. For each objective a set of applications, change drivers, requirements and possible leaders will be identified. Education processes differ among themselves because of the subject of learning, required learning outcomes, previous knowledge, learning styles, culture, industry and many other factors.

On the other hand, ICT can be used in a variety of ways in any traditional or new activity. These two factors combined derive numerous activities in educational process in which ICT is or can be implemented. In order to streamline them and to try to identify some common points and shared resources, it is proposed to group them in three sets of objectives:

• Support functions: administrative, technical and supportive functions ,

• Learning assistance: assistance and support for learning and teaching,

• New learning: new teaching and learning methods, techniques and tools.

Support functions Support functions are all those administrative, technical and supportive functions that are (considered to be) necessary in today's educational processes but which do not increase the knowledge or skills of students by themselves. In particular they are: enrolment to courses and programs, certification (a formal and administrative process as opposed to knowledge verification) and payment. They are also: scheduling of classes, exercises and exams; attendance granting and monitoring; resource allocation and usage monitoring and billing. Surveys, statistics and reports belong here, too.

Supplemental functions are provision and usage of libraries and info services, counseling and student assistance. Finally, the mere physical presence at the premises of a school is a support function, as well, Today, a substantial amount of student's and teacher's time is used for those functions. By intensive, extensive and proper use if ICT all mentioned functions can be reduced, automated, asynchronized or avoided at all. The goals should be to avoid (the need for) physical presence for all administrative activities and for all those learning activities where possible. The data which a user (student or teacher) enters into the system should be available system wide and should never be entered again.

Every function that can be described by rules and programmed should be performed by computers, automatically, not requiring human effort. The communication among all players in the educational system should be available online 24 hours a day 365 days a year using the variety of communication techniques (phone, Internet …) preferably asynchronous ones: SMS, IM, e-mail. This means that administrative information systems, automated information systems and digital libraries should be built.

Teleconferencing should be routinely used. Virtual communities need to be established providing legal assistance, support groups etc. Finally, virtual and remote labs should be designed. All the technologies exist, applications have been tested world wide and concepts proved in practice. So, what needs to be done in order to implement them on the broader scale? The change drivers fall in two categories:

financial pressure and market competition. The need for administrative cost reduction and efficient resource usage make financial pressure on school administrations. Market competition in form of increased offer from other educational institutions and new players from the industry will result in increased demand from both students and teachers to reduce non-educational burden on their time. In order for those changes to take place, certain requirements need to be met: educational institutions need to be (at least partially) cost based instead of fixed budget, students need to be empowered and regulational framework in place supporting remote work and education in general.

Finally, the leaders of change need to be identified. In this case these are students, their organizations and leaders and leaders from administration (school, local, or national) .

Learning assistance Learning assistance are all those functions that provide assistance and support for learning and teaching. They are closely related or bound to learning content and process but do not directly increase student's knowledge or skills in the learning domain. They are comprised of resources and systems that make learning and teaching faster, easier, better focused, broader and deeper thus enhancing the understanding and mastering domain knowledge and skills. They are also systems that continuously improve teacher's competences as well as student's knowledge and skills outside (but in "neighborhood") of the learning domain. The goals within this objective are to provide students with all necessary and desired information and knowledge and to do so in digital form suitable for any type of processing and manipulation they deem desirable.

A goal is also to further physically and temporally decouple student from any other individual, resource or process required or desired in learning. Assumed goal is that all necessary resources are available to a student as well as training and support to efficiently use them. An important resource in learning process are centers of excellence: points of referral when in doubt or need for clarification and assistance. These goals can be accomplished by digitizing all existing learning and teaching materials and making them available on-line, by establishing and opening digital libraries and opening all relevant digital collections and libraries world-wide to students while learning. Archives of student's results from previous generations as well as their questions and answers to them are invaluable source and aid in learning process. E-mail communication with teachers and other students, virtual (global) working groups, distance asynchronous teaching, live streaming and recordings of lectures, exercises and events greatly enhance and simplify learning process.

Computers, communications and SW tools per se but also as means to access and use other resources should be treated as resources and readily, omni presently available to students. Training and assistance for their usage are natural part of those resources. In order to create described learning assistance, change forces can come from three sources. Students will demand them as market competition increases and competitors start creating their own market advantage offering such assistance. Professional educational standards could come from teachers professional associations and education industry as the changing force. Educational community (such as university) could create “service level” requirements within themselves thus creating internal change force.

Obvious but serious obstacles in this process area associated cost and huge effort required from all involved in providing education and traditional inertia of large systems. In order for these changing forces to succeed there are requirements to be fulfilled. Above all it is necessity to honestly, substantially recognize the (importance of) teaching quality and achievement. Currently there are only few instances where a regulation would prevent development of learning by means of ICT, but significant changes in regulation are a must in order to foster it. Market competition of education providers is single most important factor that needs to be established in order to “wake up giants”. When all this is set, the infrastructure that will support e-learning needs to be in place, too.

Large financial investment is inevitable in every educational system. The final question is: who can lead the change? In part that can be students demanding resources. Majority of burden still lies on educational authorities and governance. However, teachers and their associations cannot avoid their responsibility in this change

New learning New learning is a joint name for new methods, techniques and tools in teaching and learning that substantially change the outcomes, the way and the experience of learning. They do so in the way which would be impossible, impractical or prohibitively expensive without the use of ICT. Since this is a very innovative field of ICT leverage it is difficult to set fixed goals, but on the general terms it is about full adjustment of learning process to needs and abilities of the student. It is focused on understanding and mastering knowledge modules of sustainable importance. Above all it is about putting full control of learning process in student's hands, making learning process as transparent as possible with ample reference points enabling students to measure their progress, asses acquired skills and knowledge and find their way forward in every learning situation.

These goals can be accomplished through ICT implementation in several ways. One of most innovative ways is by means of virtual laboratories in which students can perform endless experiments at no additional cost, dangerous or unethical (on simulations of human body) experiments, impossible experiments (temperatures close to absolute zero or no-gravitation environment) or experiments with compressed or elongated time line. Virtual working groups and faculty staff would add to student's ability to truly understand and grasp learning concepts. Self examination tools are those that will provide students with orientation points for their own path and milestones along it.

Self paced integrated adaptive learning materials are the ultimate goal. They are as close to the real teacher silicone technology will ever get. They will liberate teachers from tedious and routine work and concentrate their skills and energy to providing teaching, mentoring and coaching only human can. Simultaneously, students will be able to learn in the way best suits them, aiming to the goals tailored to their needs, in the process optimized to their abilities while keeping the control in their own hands. The major driver that will force change in the learning process itself is market competition. Once students experience new, enhanced learning they will demand it from all educators. Since the major burden of changing the learning process is on teachers, market competition will result in pressure from educational employers who will require teachers to improve and develop the learning process .

In addition, teacher's professional associations may come forward with new set of professional teaching standards which could serve as an auxiliary change driver. As with other objectives, market competition should not only be waited for but should be proactively created by national governments, educational communities, international associations and industry at large . Strong recognition of quality (in) teaching is a must for the changes to become sustainable. It has to be understood that new learning requires more effort on side of teachers and students likewise, plenty of time and a lot of money. In addition, since teachers and students alike are walking on a completely new path they need strong support.

In such an innovative process it is very difficult to precisely plan for required infrastructure and even more difficult to optimize its use. Therefore a stateof-the-art, abundant infrastructure needs to be provided to all players. Crucial point to understand is that innovative teachers are pioneers in this process, not leaders. Leaders can be only those who can (inter)connect ideas, pilots and new achievements, obtain resources and start the change process. In general, those are decision makers at the highest level .

Conclusion

Proposed set of objectives, goals, drivers, requirements and leaders is not the only one possible but could be used as an orientation point or guiding principle to design a similar one for the educational change desired. It is important to identify, define and design all components and put them in operation because they are all crucial. For example, even ample resources and detailed plan will bear no results if they are missing a change force or are trying to engage the wrong one. Similarly, without the proper leader there will be no sustainability and no focus in the process and thus desired results cannot be achieved.

However, if all elements are in place and are applied over the appropriate period of time, they will result in expected outcomes. Leading authors on change in educational systems agree that the major changing force are teachers. Students have very important role, too. All others are “merely” in a support function but their role is therefore not less important and their responsibility cannot be circumvented. Indeed, support functions in education like decision makers, regulators and financiers are those with the major responsibility to design the change process properly and keep it in motion. 13.

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PERSONAL COMPUTER TECHNOLOGY

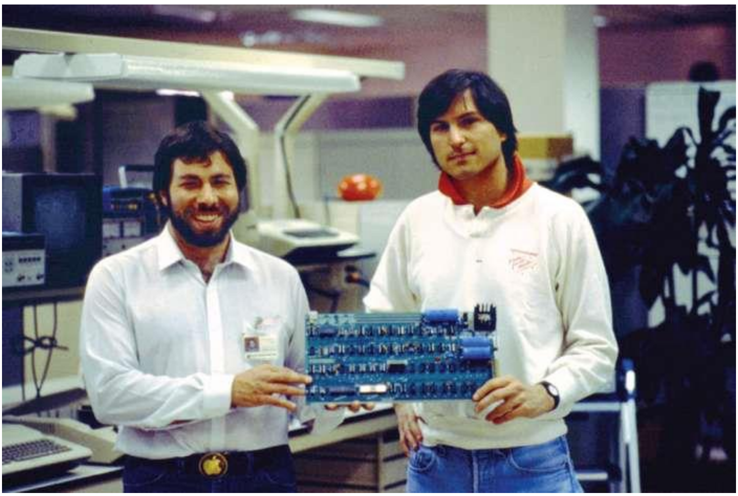
Personal computer (PC), a digital computer designed for use by only one person at a time. A typical personal computer assemblage consists of a central processing unit (CPU), which contains the computer's arithmetic, logic, and control circuitry on an integrated circuit; two types of computer memory, main memory, such as digital random-access memory (RAM), and auxiliary memory, such as magnetic hard disks and special optical compact discs, or read-only memory (ROM) discs (CD-ROMs and DVD-ROMs); and various input/output devices, including a display screen, keyboard and mouse, modem, and printer. See also computer: History of computing.

laptop computerA laptop personal computer.© Index Open

From Hobby Computers To Apple

Computers small and inexpensive enough to be purchased by individuals for use in their homes first became feasible in the 1970s, when large-scale integration made it possible to construct a sufficiently powerful microprocessor on a single semiconductor chip. A small firm named MITS made the first personal computer, the Altair. This computer, which used Intel Corporation's 8080 microprocessor, was developed in 1974. Though the Altair was popular among computer hobbyists, its commercial appeal was limited.

The personal computer industry truly began in 1977, with the introduction of three preassembled mass-produced personal computers: Apple Computer, Inc.'s (now Apple Inc.) Apple II, the Tandy Radio Shack TRS-80, and the Commodore Business Machines Personal Electronic Transactor (PET). These machines used eight-bit microprocessors (which process information in groups of eight bits, or binary digits, at a time) and possessed rather limited memory capacity—i.e., the ability to address a given quantity of data held in memory storage. But because personal computers were much less expensive than mainframe computers (the bigger computers typically deployed by large business, industry, and government organizations), they could be purchased by individuals, small and medium-sized businesses, and primary and secondary schools.



Wozniak, Steve; Jobs, SteveSteve Wozniak (left) and Steve Jobs holding an Apple I circuit board, c. 1976.Courtesy of Apple Computer, Inc.

Of these computers, the TRS-80 dominated the market. The TRS-80 microcomputer came with four kilobytes of memory, a Z80 microprocessor, a BASIC programming language, and cassettes for data storage. To cut costs, the machine was built without the ability to type lowercase letters. Thanks to Tandy's chain of Radio Shack stores and the breakthrough price ($399 fully assembled and tested), the machine was successful enough to persuade the company to introduce a more powerful computer two years later, the TRS-80 Model II, which could reasonably be marketed as a small-business computer.

The Apple II received a great boost in popularity when it became the host machine for VisiCalc, the first electronic spreadsheet (computerized accounting program). Other types of application software soon developed for personal computers.

IBM PC

IBM Corporation, the world’s dominant computer maker, did not enter the new market until 1981, when it introduced the IBM Personal Computer, or IBM PC. The IBM PC was significantly faster than rival machines, had about 10 times their memory capacity, and was backed by IBM’s large sales organization. The IBM PC was also the host machine for 1-2-3, an extremely popular spreadsheet introduced by the Lotus Development Corporation in 1982. The IBM PC became the world’s most popular personal computer, and both its microprocessor, the Intel 8088, and its operating system, which was adapted from Microsoft Corporation’s MS-DOS system, became industry standards. Rival machines that used Intel microprocessors and MS-DOS became known as “IBM compatibles” if they tried to compete with IBM on the basis of additional computing power or memory and “IBM clones” if they competed simply on the basis of low price.

The IBM Personal Computer (PC) was introduced in 1981. Microsoft supplied the machine's operating system, MS-DOS (Microsoft Disk Operating System).IBM Archives

GUI

In 1983 Apple introduced Lisa, a personal computer with a graphical user interface (GUI) to perform routine operations. A GUI is a display format that allows the user to select commands, call up files, start programs, and do other routine tasks by using a device called a mouse to point to pictorial symbols (icons) or lists of menu choices on the screen. This type of format had certain advantages over interfaces in which the user typed text- or character-based commands on a keyboard to perform routine tasks.

A GUI’s windows, pull-down menus, dialog boxes, and other controlling mechanisms could be used in new programs and applications in a standardized way, so that common tasks were always performed in the same manner. The Lisa’s GUI became the basis of Apple’s Macintosh personal computer, which was introduced in 1984 and proved extremely successful. The Macintosh was particularly useful for desktop publishing because it could lay out text and graphics on the display screen as they would appear on the printed page.

Apple's Lisa computerCourtesy of Apple Computer, Inc.

The Macintosh’s graphical interface style was widely adapted by other manufacturers of personal computers and PC software. In 1985 the Microsoft Corporation introduced Microsoft Windows, a graphical user interface that gave MS-DOS-based computers many of the same capabilities of the Macintosh. Windows became the dominant operating environment for personal computers.

These advances in software and operating systems were matched by the development of microprocessors containing ever-greater numbers of circuits, with resulting increases in the processing speed and power of personal computers. The Intel 80386 32-bit microprocessor(introduced 1985) gave the Compaq Computer Corporation’s Compaq 386 (introduced 1986) and IBM’s PS/2 family of computers (introduced 1987) greater speed and memory capacity. Apple’s Mac II computer family made equivalent advances with microprocessors made by Motorola, Inc. The memory capacity of personal computers had increased from 64 kilobytes (64,000 characters) in the late 1970s to 100 megabytes (100 million characters) by the early ’90s to several gigabytes (billions of characters) by the early 2000s.

The Compaq portable computer Compaq Computer Corporation introduced the first IBM-compatible portable computer in November 1982. At a weight of about 25 pounds (11 kilograms), it was sometimes referred to as a “luggable” computer. Courtesy of Compaq Computer Corp.

By 1990 some personal computers had become small enough to be completely portable. They included laptop computers, also known as notebook computers, which were about the size of a notebook, and less-powerful pocket-sized computers, known as personal digital assistants (PDAs). At the high end of the PC market, multimedia personal computers equipped with DVD players and digital sound systems allowed users to handle animated images and sound (in addition to text and still images) that were stored on high-capacity DVD-ROMs. Personal computers were increasingly interconnected with each other and with larger computers in networks for the purpose of gathering, sending, and sharing information electronically. The uses of personal computers continued to multiply as the machines became more powerful and their application software proliferated.

The Palm Pilot personal digital assistant (PDA)Introduced in March 1997, this PDA model was equipped with enough processing power to store and manipulate personal information, as well as handle the most common scheduling tasks. Courtesy of 3Com Corporation

By 2000 more than 50 percent of all households in the United States owned a personal computer, and this penetration increased dramatically over the next few years as people in the United States (and around the world) purchased PCs to access the world of information available through the Internet.

The nonprofit One Laptop per Child project sought to provide a cheap (about $100), durable, energy-efficient computer to every child in the world, especially those in less-developed countries.

As the 2000s progressed, the calculation and video display distinctions between mainframe computers and PCs continued to blur: PCs with multiple microprocessors became more common; microprocessors that contained more than one "core" (CPU) displaced single-core microchips in the PC market; and high-end graphic processing cards, essential for playing the latest electronic games, became standard on all but the cheapest PCs. Likewise, the processor speed, amount and speed of memory, and data-storage capacities of PCs reached or exceeded the levels of earlier supercomputers.

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The personal computer

In late 1976 Commodore Business Machines, an established electronics firm that had been active in producing electronic calculators, bought a small hobby-computer company named MOS Technology. For the first time, an established company with extensive distribution channels…

The personal computer revolution

Before 1970, computers were big machines requiring thousands of separate transistors. They were operated by specialized technicians, who often dressed in white lab coats and were commonly referred to as a computer priesthood. The machines were expensive and difficult to use. Few…

electronic game: Personal computer games

By the late 1970s, electronic games could be designed not only for large university-based shared computers, video consoles, and arcade machines but also for the new breed of home computers equipped with their own general-purpose microprocessors and operating systems that could run…

PDA, in full personal digital assistant, a handheld organizer used to store contact information, manage calendars, communicate by e-mail, and handle documents and spreadsheets, usually in communication with the user’s personal computer.

Palm Pilot personal digital assistant (PDA).Courtesy of 3Com Corporation

computer: Handheld digital devices

” The origins of handheld digital devices go back to the 1960s, when Alan Kay, a researcher at Xerox’s Palo Alto Research Center (PARC),…

The first PDAs were developed in the early 1990s as digital improvements upon the traditional pen-and-paper organizers used to record personal information such as telephone numbers, addresses, and calendars. The first electronic organizers were large, had limited capabilities, and were often incompatible with other electronic systems. As computer technology improved, however, so did personal organizers. Soon companies such as Sharp Electronics Corporation, Casio Computer Company, and Psion PLC developed more-efficient models. Those PIMs, or personal information managers, were more user-friendly and could connect to personal computers (PCs), and they had stylus interfaces and upgrade capabilities. In addition, later versions offered e-mail access and the option to download e-books. These improved devices still faced compatibility issues, however.

In 1993 Apple Inc. released the Newton MessagePad, for which John Sculley, then Apple’s chief executive officer, coined the term PDA. Although an improvement in some areas, the Newton’s handwriting recognition was only 85 percent effective, resulting in ridicule and poor sales.

In 1996 Palm, Inc., released the first Palm Pilot PDAs, which quickly became the model for other companies to follow. The Pilot did not try to replace the computer but made it possible to organize and carry information with an electronic calendar, a telephone number and address list, a memo pad, and expense-tracking software and to synchronize that data with a PC. The device included an electronic cradle to connect to a PC and pass information back and forth. It also featured a data-entry system called "graffiti," which involved writing with a stylus using a slightly altered alphabet that the device recognized. Its success encouraged numerous software companies to develop applications for it.

In 1998 Microsoft Corporation produced Windows CE, a stripped-down version of its Windows OS(operating system), for use on mobile devices such as PDAs. This encouraged several established consumer electronics firms to enter the handheld organizer market. These small devices also often possessed a communications component and benefited from the sudden popularization of the Internet and the World Wide Web. In particular, the BlackBerry PDA, introduced by the Canadian company Research in Motion in 2002, established itself as a favourite in the corporate world because of features that allowed employees to make secure connections with their companies' databases.

The BlackBerry personal digital assistant (PDA), manufactured by the Canadian company Research in Motion.PRNewsFoto/Verizon Wireless/AP Images

Most new PDAs are easy to use and feature keyboards, colour displays, touch screens, sound, increased memory, PC connectivity, improved software (including e-mail and word-processing programs), and wireless Internet access. In addition, technologies such as Bluetooth allow PDAs to communicate wirelessly with a user's primary computer and with other users' PDAs. Most PDAs also offer extensive music storage capabilities as well as access to telephone networks, either through the Internet or through traditional cellular telephone technologies. These latter capabilities have tended to cross the line into market territory dominated by smartphones. Indeed, the steady growth of smartphone sales has coincided with a decline in sales of PDAs, leading some market researchers to predict that PDAs eventually will disappear or perhaps settle into a more-modest niche of business users who have no need for the numerous personal and multimedia services available on smartphones.

computer: Handheld digital devices

” The origins of handheld digital devices go back to the 1960s, when Alan Kay, a researcher at Xerox’s Palo Alto Research Center (PARC), promoted the vision of a small, powerful notebook-style computer that he called the Dynabook. Kay never actually built a…

Palm OS

…including personal digital assistants (PDAs), "smart phones" (telephones with PDA-like features), handheld gaming systems, and Global Positioning System (GPS) devices. More than 17,000 applications have been created for the Palm OS by licensed developers.…

microcomputer

…palm-sized, computers, commonly known as personal digital assistants (PDAs), are distinguished by their high portability, enhanced performance, and low cost. Similarly, microprocessors began finding their way into cellular telephones and portable MP3 music players.…

NEC Corporation, major Japanese multinational corporation, producer of telecommunications equipment and related software and services. Headquarters are in Tokyo.

NEC CorporationNEC Corporation headquarters, Tokyo.KW

Nippon Electric Company, Ltd. (NEC; officially NEC Corporation in 1983), was founded in 1899 with funding from the Western Electric Company of the United States. The Japanese partner in this new venture was Iwadare Kunihiko, an expert in telegraphic systems who had worked for 10 years in the United States under the American inventor Thomas Alva Edison. NEC was the first Japanese joint venture with a foreign company, and it paved the way for Western Electric to export its telephone equipment to the Japanese government.

As Western Electric gradually gained confidence in the integrity of Japan’s system of administering patents, it offered technical support that eventually enabled NEC to manufacture, rather than merely assemble, telephone equipment.

In 1924 NEC began its own radio communications business, helping to usher in Radio Tokyo, the first broadcast station in Japan. In 1928 NEC used telephotography equipment it had developed (a precursor to the facsimile machine) to transmit photographs of the coronation of Emperor Hirohito from Kyōto to Tokyo, a feat that had a great impact on the Japanese population.

Because of its strategic position as the main supplier of equipment to Japan’s Ministry of Communication, the predecessor to Japan’s telephone utility, NEC was involved in efforts to modernize the country’s communications infrastructure. In the 1930s NEC established the first telephone connection between Japan and China, by developing and installing 3,000 km (1,900 miles) of cable and equipment. Government support was also instrumental in NEC’s establishment of its first research and development laboratory in 1939, especially as Japan attempted to wean itself from foreign dependencies in the years leading up to World War II.

By 1954 NEC had embarked on computer research and development, including a project to produce a computer using parametrons, a Japanese switching technology (similar to magnetic cores) that was more stable than vacuum tubes and less expensive than early transistors. In 1958 NEC used this technology to build the NEAC-1101, the first Japanese computer system that was not based on an IBM-compatible design. The next year, NEC built its first fully transistorized computer, the NEAC 2201.

Like other Japanese electronics firms, NEC was encouraged by Japan's Ministry of International Trade and Industry to collaborate with an American company in order to gain access to technology in exchange for marketing the American company's goods in Japan. In 1962 NEC signed a 10-year accord with Honeywell Inc. Soon NEC began manufacturing the NEAC 2200 (in essence, Honeywell's H200) to compete directly with IBM.

A concerted effort at global expansion was initiated in 1964 when Kobayashi Koji became NEC's president, propelling the company's growth, which until that time had relied heavily on sales to the Japanese government. Throughout the 1960s and '70s, NEC continued to penetrate the burgeoning global computer market. In the 20 years between 1964 and 1984, NEC's total sales grew from $270 million to $8 billion, 35 percent of which was in overseas business.

In Europe NEC participated in joint research and development of equipment and operating systems with Honeywell and the French government-controlled computer company Fédération des Equipes Bull, especially after 1970 when Honeywell took over General Electric Co.'s position in Bull-General Electric. In 1987 Honeywell, Bull, and NEC formed Honeywell-Bull Inc., with 42.5, 42.5, and 15 percent ownership, respectively. Although Honeywell had dropped out by the early 1990s, NEC maintained its investment, and, as the French government privatized the company, NEC emerged as Bull's largest shareholder.

In the United States, Japanese semiconductor companies were overtaking their American counterparts during the 1970s, putting pressure on the U.S. government for protectionist legislation. In response, NEC acquired Electronic Arrays, Inc., in 1978, becoming one of the first Japanese companies to locate some of its semiconductor operations in the United States.

In 1977 NEC announced its “C&C” (computers and communications) campaign, two areas of technology that Kobayashi envisioned as melding into one. As Japan’s preeminent telecommunications company, NEC contributed to developments in mobile telephony, fiber optic networks, private branch exchanges, and microwave, digital, and satellite communications systems. In 2000 NEC reorganized its corporate structure to facilitate Internet-related sales and service.

Besides mainframe computers, NEC was an early developer and marketer of personal computers. In 1997 NEC merged its North American personal computer operations with Zenith Data Systems and Packard Bell to form Packard Bell–NEC, Inc., but the new company was unsuccessful and closed in 1999.

NEC also became a premier supercomputer developer. With billions of dollars in funding from the Japanese government, NEC engineered a custom computer processor for its Earth Simulator. Operational in 2002, the machine used more than 5,000 processors and outperformed its nearest rival, the IBM ASCI White, fivefold. The Earth Simulator was built to model the weather—in particular, to give the government advance warning of typhoon conditions.

In 2002 NEC spun off its semiconductor manufacturing business into a new company, NEC Electronics, which merged with Renesas Technology in 2010 to form Renesas Electronics. NEC formed a joint venture with the Chinese personal computer maker Lenovo in 2011. The joint venture, Lenovo NEC Holdings, had about 25 percent of the Japanese personal computer market and was almost completely acquired by Lenovo in 2016.

II VARIANT

A personal computer (PC) is a multi-purpose computer whose size, capabilities, and price make it feasible for individual use. Personal computers are intended to be operated directly by an end user, rather than by a computer expert or technician. Unlike large costly minicomputer and mainframes, time-sharing by many people at the same time is not used with personal computers.

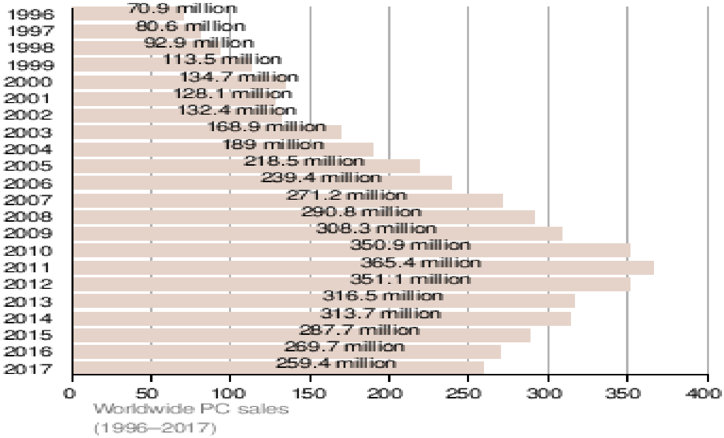
Institutional or corporate computer owners in the 1960s had to write their own programs to do any useful work with the machines. While personal computer users may develop their own applications, usually these systems run commercial software, free-of-charge software ("freeware"), which is most often proprietary, or free and open-source software, which is provided in "ready-to-run", or binary, form. Software for personal computers is typically developed and distributed independently from the hardware or operating system manufacturers. Many personal computer users no longer need to write their own programs to make any use of a personal computer, although end-user programming is still feasible. This contrasts with mobile systems, where software is often only available through a manufacturer-supported channel, and end-user program development may be discouraged by lack of support by the manufacturer.

Since the early 1990s, Microsoft operating systems and Intel hardware have dominated much of the personal computer market, first with MS-DOS and then with Microsoft Windows. Alternatives to Microsoft's Windows operating systems occupy a minority share of the industry. These include Apple's mac OS and free and open-source Unix-like operating systems.

The advent of personal computers and the concurrent Digital Revolution have significantly affected the lives of people in all countries.

"PC" is an initialism for "personal computer". The IBM Personal Computer incorporated the designation in its model name. It is sometimes useful to distinguish personal computers of the "IBM Personal Computer" family from personal computers made by other manufacturers. For example, "PC" is used in contrast with "Mac", an Apple Macintosh computer. Since none of these Apple products were mainframes or time-sharing systems, they were all "personal computers" and not "PC" (brand) computers.

Commodore PET in 1983 (at American Museum of Science and Energy), an early example of a personal computer



The "brain" [computer] may one day come down to our level [of the common people] and help with our income-tax and book-keeping calculations. But this is speculation and there is no sign of it so far.

— British newspaper The Star in a June 1949 news article about the EDSAC computer, long before the era of the personal computers.

In the history of computing, early experimental machines could be operated by a single attendant. For example, ENIAC which became operational in 1946 could be run by a single, albeit highly trained, person. This mode pre-dated the batch programming, or time-sharing modes with multiple users connected through terminals to mainframe computers.

Computers intended for laboratory, instrumentation, or engineering purposes were built, and could be operated by one person in an interactive fashion. Examples include such systems as the Bendix G15 and LGP-30of 1956, the Programma 101 introduced in 1964, and the Soviet MIR series of computers developed from 1965 to 1969. By the early 1970s, people in academic or research institutions had the opportunity for single-person use of a computer system in interactive mode for extended durations, although these systems would still have been too expensive to be owned by a single person.

The Italian Programma 101 was a programmable calculator produced by Olivetti in 1964

The personal computer was made possible by major advances in semiconductor technology. In 1959, the silicon integrated circuit (IC) chip was developed by Robert Noyce at Fairchild Semiconductor, and the metal-oxide-semiconductor (MOS) transistor was developed by Mohamed Atalla and Dawon Kahng at Bell Labs. The MOS integrated circuit was commercialized by RCA in 1964, and then the silicon-gate MOS integrated circuit was developed by Federico Faggin at Fairchild in 1968. Faggin later used silicon-gate MOS technology to develop the first single-chip microprocessor, the Intel 4004, in 1971. The first microcomputers, based on microprocessors, were developed during the early 1970s. Widespread commercial availability of microprocessors, from the mid-1970s onwards, made computers cheap enough for small businesses and individuals to own.

In what was later to be called the Mother of All Demos, SRI researcher Douglas Engelbart in 1968 gave a preview of features that would later become staples of personal computers: e-mail, hypertext, word processing, video conferencing, and the mouse. The demonstration required technical support staff and a mainframe time-sharing computer that were far too costly for individual business use at the time.

Early personal computers—generally called microcomputers—were often sold in a kit form and in limited volumes, and were of interest mostly to hobbyists and technicians. Minimal programming was done with toggle switches to enter instructions, and output was provided by front panel lamps. Practical use required adding peripherals such as keyboards, computer displays, disk drives, and printers.

Micral N was the earliest commercial, non-kit microcomputer based on a microprocessor, the Intel 8008. It was built starting in 1972, and a few hundred units were sold. This had been preceded by the Data point 2200 in 1970, for which the Intel 8008 had been commissioned, though not accepted for use. The CPU design implemented in the Datapoint 2200 became the basis for x86 architecture used in the original IBM PC and its descendants.

In 1973, the IBM Los Gatos Scientific Center developed a portable computer prototype called SCAMP (Special Computer APL Machine Portable) based on the IBM PALMprocessor with a Philips compact cassette drive, small CRT, and full function keyboard. SCAMP emulated an IBM 1130 minicomputer in order to run APL/1130. In 1973, APL was generally available only on mainframe computers, and most desktop sized microcomputers such as the Wang 2200 or HP 9800 offered only BASIC. Because SCAMP was the first to emulate APL/1130 performance on a portable, single user computer, PC Magazine in 1983 designated SCAMP a "revolutionary concept" and "the world's first personal computer".

This seminal, single user portable computer now resides in the Smithsonian Institution, Washington, D.C.. Successful demonstrations of the 1973 SCAMP prototype led to the IBM 5100 portable microcomputer launched in 1975 with the ability to be programmed in both APL and BASIC for engineers, analysts, statisticians, and other business problem-solvers. In the late 1960s such a machine would have been nearly as large as two desks and would have weighed about half a ton.

Another desktop portable APL machine, the MCM/70, was demonstrated in 1973 and shipped in 1974. It used the Intel 8008 processor.

A seminal step in personal computing was the 1973 Xerox Alto, developed at Xerox's Palo Alto Research Center (PARC). It had a graphical user interface (GUI) which later served as inspiration for Apple's Macintosh, and Microsoft's Windows operating system. The Alto was a demonstration project, not commercialized, as the parts were too expensive to be affordable.

Also in 1973 Hewlett Packard introduced fully BASIC programmable microcomputers that fit entirely on top of a desk, including a keyboard, a small one-line display, and printer. The Wang 2200microcomputer of 1973 had a full-size cathode ray tube (CRT) and cassette tape storage. These were generally expensive specialized computers sold for business or scientific uses.

Altair 8800 computer

1974 saw the introduction of what is considered by many to be the first true "personal computer", the Altair 8800 created by Micro Instrumentation and Telemetry Systems (MITS). Based on the 8-bit Intel 8080 Microprocessor, the Altair is widely recognized as the spark that ignited the microcomputer revolution as the first commercially successful personal computer. The computer bus designed for the Altair was to become a de facto standard in the form of the S-100 bus, and the first programming language for the machine was Microsoft's founding product, Altair BASIC.

In 1976, Steve Jobs and Steve Wozniak sold the Apple I computer circuit board, which was fully prepared and contained about 30 chips. The Apple I computer differed from the other kit-style hobby computers of era. At the request of Paul Terrell, owner of the Byte Shop, Jobs and Wozniak were given their first purchase order, for 50 Apple I computers, only if the computers were assembled and tested and not a kit computer. Terrell wanted to have computers to sell to a wide range of users, not just experienced electronics hobbyists who had the soldering skills to assemble a computer kit. The Apple I as delivered was still technically a kit computer, as it did not have a power supply, case, or keyboard when it was delivered to the Byte Shop.

The three personal computers referred to by Byte Magazine as the "1977 Trinity" of home computing: The Commodore PET, the Apple II, and the TRS-80 Model I.

The first successfully mass marketed personal computer to be announced was the Commodore PET after being revealed in January 1977. However, it was back-ordered and not available until later that year. Three months later (April), the Apple II(usually referred to as the "Apple") was announced with the first units being shipped 10 June 1977, and the TRS-80 from Tandy Corporation / Tandy Radio Shack following in August 1977, which sold over 100,000 units during its lifetime. Together, these 3 machines were referred to as the "1977 trinity". Mass-market, ready-assembled computers had arrived, and allowed a wider range of people to use computers, focusing more on software applications and less on development of the processor hardware.

In 1977 the Heath company introduced personal computer kits known has Heathkits, starting with the Heathkit H8, followed by the Heathkit H89 in late 1979. With the purchase of the Heathkit H8 you would obtain the chassis and CPU card to assemble yourself, additional hardware such as the H8-1 memory board that contained 4k of RAM could also be purchased in order to run software. The Heathkit H11 model was released in 1978 and was one of the first 16-bit personal computers, however due to its high retail cost of $1,295 was discontinued in 1982.

IBM 5150, released in 1981

The 8-bit PMD 85 personal computer produced in 1985–1990 by the Tesla company in the former socialist Czechoslovakia

During the early 1980s, home computers were further developed for household use, with software for personal productivity, programming and games. They typically could be used with a television already in the home as the computer display, with low-detail blocky graphics and a limited color range, and text about 40 characters wide by 25 characters tall. Sinclair Research, a UK company, produced the ZX Series—the ZX80 (1980), ZX81 (1981), and the ZX Spectrum; the latter was introduced in 1982, and totaled 8 million unit sold. Following came the Commodore 64, totaled 17 million units sold and the Amstrad CPC series (464–6128).

In the same year, the NEC PC-98 was introduced, which was a very popular personal computer that sold in more than 18 million units. Another famous personal computer, the revolutionary Amiga 1000, was unveiled by Commodore on July 23, 1985. The Amiga 1000 featured a multitasking, windowing operating system, color graphics with a 4096-color palette, stereo sound, Motorola 68000 CPU, 256 KB RAM, and 880 KB 3.5-inch disk drive, for US$1,295.

Somewhat larger and more expensive systems were aimed at office and small business use. These often featured 80-column text displays but might not have had graphics or sound capabilities. These microprocessor based systems were still less costly than time-shared mainframes or minicomputers.

Workstations were characterized by high-performance processors and graphics displays, with large-capacity local disk storage, networking capability, and running under a multitasking operating system. Eventually, due to the influence of the IBM PC on the personal computer market, personal computers and home computers lost any technical distinction. Business computers acquired color graphics capability and sound, and home computers and game systems users used the same processors and operating systems as office workers. Mass-market computers had graphics capabilities and memory comparable to dedicated workstations of a few years before. Even local area networking, originally a way to allow business computers to share expensive mass storage and peripherals, became a standard feature of personal computers used at home.

IBM's first PC was introduced Aug. 12, 1981.

In 1982 "The Computer" was named Machine of the Year by Time magazine. In the 2010s, several companies such as Hewlett-Packard and Sony sold off their PC and laptop divisions. As a result, the personal computer was declared dead several times during this period.

An increasingly important set of uses for personal computers relied on the ability of the computer to communicate with other computer systems, allowing interchange of information. Experimental public access to a shared mainframe computer system was demonstrated as early as 1973 in the Community Memory project, but bulletin board systems and online service providers became more commonly available after 1978. Commercial Internet service providers emerged in the last 1980's, giving public access to the rapidly growing network.

In 1991, the World Wide Web was made available for public use. The combination of powerful personal computers with high resolution graphics and sound, with the infrastructure provided by the Internet, and the standardization of access methods of the Web browsers, established the foundation for a significant fraction of modern life, from bus time tables through unlimited distribution of free pornography through to online user-edited encyclopedias.

Personal Computers' Types

Workstation

Sun SPARCstation 1+ from the early 1990s, with a 25 MHz RISCprocessor

A workstation is a high-end personal computer designed for technical, mathematical, or scientific applications.

Intended primarily to be used by one person at a time, they are commonly connected to a local area network and run multi-user operating systems.

Workstations are used for tasks such as computer-aided design, drafting and modeling, computation-intensive scientific and engineering calculations, image processing, architectural modeling, and computer graphics for animation and motion picture visual effects.

Desktop computer

A Dell OptiPlex desktop computer

Before the widespread use of PCs, a computer that could fit on a desk was remarkably small, leading to the "desktop" nomenclature. More recently, the phrase usually indicates a particular style of computer case. Desktop computers come in a variety of styles ranging from large vertical tower cases to small models which can be tucked behind or rest directly beneath (and support) LCD monitors.

While the term "desktop" often refers to a computer with a vertically aligned computer tower case, these varieties usually rest on the ground or underneath desks. Despite this seeming contradiction, the term "desktop" does typically refer to these vertical tower cases as well as the horizontally aligned models which are designed to literally rest on top of desks and are therefore more appropriate to the "desktop" term, although both types qualify for this "desktop" label in most practical situations aside from certain physical arrangement differences. Both styles of these computer cases hold the systems hardware components such as the motherboard, processor chip, other internal operating parts. Desktop computers have an external monitor with a display screen and an external keyboard, which are plugged into USB ports on the back of the computer case. Desktop computers are popular for home and business computing applications as they leave space on the desk for multiple monitors.

A gaming computer is a desktop computer that generally comprises a high-performance video card, processor and memory, to improve the speed and responsiveness of demanding video games.

An all-in-one computer (also known as single-unit PCs) is a desktop computer that combines the monitor and processor within a single unit. A separate keyboard and mouse are standard input devices, with some monitors including touchscreen capability. The processor and other working components are typically reduced in size relative to standard desktops, located behind the monitor, and configured similarly to laptops.

A nettops computer was introduced by Intel in February 2008, characterized by low cost and lean functionality. These were intended to be used with an Internet connection to run Web browsers and Internet applications.

An Antec Fusion V2 home theater PC, with a keyboard placed on top of it

A Home theater PC (HTPC) combines the functions of a personal computer and a digital video recorder. It is connected to a TV set or an appropriately sized computer display, and is often used as a digital photo viewer, music and video player, TV receiver, and digital video recorder. HTPCs are also referred to as media center systems or media servers. The goal is to combine many or all components of a home theater setup into one box. HTPCs can also connect to services providing on-demand movies and TV shows. HTPCs can be purchased pre-configured with the required hardware and software needed to add television programming to the PC, or can be assembled from components.

Portable

The potential utility of portable computers was apparent early on. Alan Kay described the Dynabook in 1972, but no hardware was developed. The Xerox NoteTaker was produced in a very small experimental batch around 1978. In 1975, the IBM 5100 could be fit into a transport case, making it a portable computer, but it weighed about 50 pounds.

Before the introduction of the IBM PC, portable computers consisting of a processor, display, disk drives and keyboard, in a suit-case style portable housing, allowed users to bring a computer home from the office or to take notes at a classroom. Examples include the Osborne 1 and Kaypro; and the Commodore SX-64. These machines were AC powered and included a small CRT display screen. The form factor was intended to allow these systems to be taken on board an airplane as carry-on baggage, though their high power demand meant that they could not be used in flight. The integrated CRT display made for a relatively heavy package, but these machines were more portable than their contemporary desktop equals. Some models had standard or optional connections to drive an external video monitor, allowing a larger screen or use with video projectors.

IBM PC-compatible suitcase format computers became available soon after the introduction of the PC, with the Compaq Portable being a leading example of the type. Later models included a hard drive to give roughly equivalent performance to contemporary desk top computers.

The development of thin plasma display and LCD screens permitted a somewhat smaller form factor, called the "lunchbox" computer. The screen formed one side of the enclosure, with a detachable keyboard and one or two half-height floppy disk drives, mounted facing the ends of the computer. Some variations included a battery, allowing operation away from AC outlets.

Notebook computers such as the TRS-80 Model 100 and Epson HX-20 had roughly the plan dimensions of a sheet of typing paper (ANSI A or ISO A4). These machines had a keyboard with slightly reduced dimensions compared to a desktop system, and a fixed LCD display screen coplanar with the keyboard. These displays were usually small, with 8 to 16 lines of text, sometimes only 40 columns line length. However, these machines could operate for extended times on disposable or rechargeable batteries. Although they did not usually include internal disk drives, this form factor often included a modem for telephone communication and often had provisions for external cassette or disk storage. Later, clam-shell format laptop computers with similar small plan dimensions were also called "notebooks".

Laptop

A laptop computer

A laptop computer is designed for portability with "clamshell" design, where the keyboard and computer components are on one panel, with a hinged second panel containing a flat display screen. Closing the laptop protects the screen and keyboard during transportation. Laptops generally have a rechargeable battery, enhancing their portability. To save power, weight and space, laptop graphics cards are in many cases integrated into the CPU or chipset and use system RAM, resulting in reduced graphics performance when compared to a desktop machine. For this reason, desktop computers are usually preferred over laptops for gaming purposes.

Unlike desktop computers, only minor internal upgrades (such as memory and hard disk drive) are feasible owing to the limited space and power available. Laptops have the same input and output ports as desktops, for connecting to external displays, mice, cameras, storage devices and keyboards. Laptops are also a little more expensive compared to desktops, as the miniaturized components for laptops themselves are expensive.

An Acer Aspire desktop replacement laptop

A desktop replacement computer is a portable computer that provides the full capabilities of a desktop computer. Such computers are currently large laptops. This class of computers usually includes more powerful components and a larger display than generally found in smaller portable computers, and may have limited battery capacity or no battery.

An HP netbook

Netbooks, also called mini notebooks or subnotebooks, were a subgroup of laptops suited for general computing tasks and accessing web-based applications. Initially, the primary defining characteristic of netbooks was the lack of an optical disc drive, smaller size, and lower performance than full-size laptops. By mid-2009 netbooks had been offered to users "free of charge", with an extended service contract purchase of a cellular data plan.

Tablet

HP Compaq tablet PC with rotating/removable keyboard

A tablet uses a touchscreen display, which can be controlled using either a stylus pen or finger.

Some tablets may use a "hybrid" or "convertible" design, offering a keyboard that can either be removed as an attachment, or a screen that can be rotated and folded directly over top the keyboard.

Some tablets may use desktop-PC operating system such as Windows or Linux, or may run an operating system designed primarily for tablets.

Many tablet computers have USB ports, to which a keyboard or mouse can be connected.

Smartphone

The LG G4, a typical smartphone

Smartphones are often similar to tablet computers, the difference being that smartphones always have cellular integration. They are generally smaller than tablets, and may not have a slate form factor.

Ultra-mobile PC

A Samsung Q1 Ultra UMPC

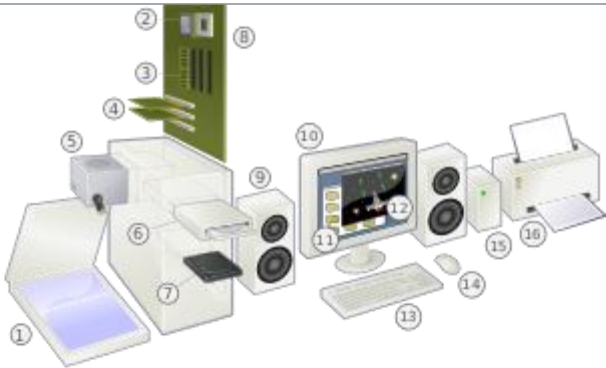
The ultra-mobile PC (UMP) is a small tablet computer. It was developed by Microsoft, Intel and Samsung, among others. Current UMPCs typically feature the Windows XP, Windows Vista, Windows 7, or Linux operating system, and low-voltage Intel Atom or VIA C7-M processors.

Pocket PC

An O_2 pocket PC

A pocket PC is a hardware specification for a handheld-sized computer (personal digital assistant, PDA) that runs the Microsoft Windows Mobile operating system. It may have the capability to run an alternative operating system like Net BSD or Linux. Pocket PCs have many of the capabilities of desktop PCs. Numerous applications are available for handhelds adhering to the Microsoft Pocket PC specification, many of which are freeware. Microsoft-compliant Pocket PCs can also be used with many other add-ons like GPS receivers, barcode readers, RFID readers and cameras. In 2007, with the release of Windows Mobile 6, Microsoft dropped the name Pocket PC in favor of a new naming scheme: devices without an integrated phone are called Windows Mobile Classic instead of Pocket PC, while devices with an integrated phone and a touch screen are called Windows Mobile Professional.

HARDWARE



An exploded view of a personal computer and peripherals (some of which are optional):

1. Scanner
2. CPU (microprocessor)
3. Memory (RAM)
4. Expansion cards (graphics cards, etc.)
5. Power supply
6. Optical disc drive
7. Storage (hard disk or SSD)
8. Motherboard
9. Speakers

10. Monitor
11. System software
12. Application software
13. Keyboard
14. Mouse
15. External hard disk
16. Printer

Computer hardware is a comprehensive term for all physical and tangible parts of a computer, as distinguished from the data it contains or operates on, and the software that provides instructions for the hardware to accomplish tasks. Some sub-systems of a personal computer may contain processors that run a fixed program, or firmware, such as a keyboard controller. Firmware usually is not changed by the end user of the personal computer.

Most 2010s-era computers only require users to plug in the power supply, monitor, and other cables. A typical desktop computer consists of a computer case (or "tower"), a metal chassis that holds the power supply, motherboard, hard disk drive, and often an optical disc drive. Most towers have empty space where users can add additional components. External devices such as a computer monitor or visual display unit, keyboard, and a pointing device (mouse) are usually found in a personal computer.

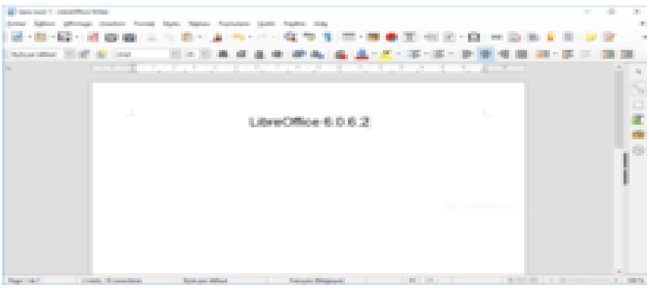
The motherboard connects all processor, memory and peripheral devices together. The RAM, graphics card and processor are in most cases mounted directly onto the motherboard. The central processing unit (microprocessor chip) plugs into a CPU socket, while the memory modules plug into corresponding memory sockets. Some motherboards have the video display adapter, sound and other peripherals integrated onto the motherboard, while others use expansion slots for graphics cards, network cards, or other I/O devices. The graphics card or sound card may employ a break out box to keep the analog parts away from the electromagnetic radiation inside the computer case. Disk drives, which provide mass storage, are connected to the motherboard with one cable, and to the power supply through another cable. Usually, disk drives are mounted in the same case as the motherboard; expansion chassis are also made for additional disk storage.

For large amounts of data, a tape drive can be used or extra hard disks can be put together in an external case. The keyboard and the mouse are external devices plugged into the computer through connectors on an I/O panel on the back of the computer case. The monitor is also connected to the input/output (I/O) panel, either through an onboard port on the motherboard, or a port on the graphics card. Capabilities of the personal computers hardware can sometimes be extended by the addition of expansion cards connected via an expansion bus. Standard peripheral buses often used for adding expansion cards in personal computers include PCI, PCI Express (PCIe), and AGP (a high-speed PCI bus dedicated to graphics adapters, found in older computers). Most modern personal computers have multiple physical PCI Express expansion slots, with some of the having PCI slots as well.

A peripheral is "a device connected to a computer to provide communication (such as input and output) or auxiliary functions (such as additional storage)". Peripherals generally connect to the computer through the use of USB ports or inputs located on the I/O panel. USB Flash Drives provide portable storage using flash memory which allows users to access the files stored on the drive on any computer. Memory cards also provide portable storage for users, commonly used on other electronics such as mobile phones and digital cameras, the information stored on these cards can be accessed using a memory card reader to transfer data between devices.

Webcams, which are either built into computer hardware or connected via USB are video cameras that records video in real time to either be saved to the computer or streamed somewhere else over the internet. Game controllers can be plugged in via USB and can be used as an input device for video games as an alternative to using keyboard and mouse.

Headphones and speakers can be connected via USB or through an auxiliary port (found on I/O panel) and allow users to listen to audio accessed on their computer, however speakers may also require an additional power source to operate. Microphones can be connected through an audio input port on the I/O panel and allow the computer to convert sound into an electrical signal to be used or transmitted by the computer.



A screenshot of the LibreOffice Writer software

Computer software is any kind of computer program, procedure, or documentation that performs some task on a computer system. The term includes application software such as word processors that perform productive tasks for users, system software such as operating systems that interface with computer hardware to provide the necessary services for application software, and middleware that controls and co-ordinates distributed systems.

A screenshot of GIMP, which is a raster graphics editor.

Software applications are common for word processing, Internet browsing, Internet faxing, e-mail and other digital messaging, multimedia playback, playing of computer game, and computer programming. The user may have significant knowledge of the operating environment and application programs, but is not necessarily interested in programming nor even able to write programs for the computer.

Therefore, most software written primarily for personal computers tends to be designed with simplicity of use, or "user-friendliness" in mind. However, the industry continuously provide a wide range of new products for use in personal computers, targeted at both the expert and the non-expert user.

OPERATING SYSTEM

An operating system (OS) manages computer resources and provides programmers with an interface used to access those resources. An operating system processes system data and user input, and responds by allocating and managing tasks and internal system resources as a service to users and programs of the system. An operating system performs basic tasks such as controlling and allocating memory, prioritizing system requests, controlling input and output devices, facilitating computer networking, and managing files.

Common contemporary desktop operating systems are Microsoft Windows, macOS, Linux, Solaris and FreeBSD.

Windows, macOS, and Linux all have server and personal variants. With the exception of Microsoft Windows, the designs of each of them were inspired by or directly inherited from the Unix operating system.

Early personal computers used operating systems that supported command line interaction, using an alphanumeric display and keyboard. The user had to remember a large range of commands to, for example, open a file for editing or to move text from one place to another. Starting in the early 1960s, the advantages of a graphical user interface began to be explored, but widespread adoption required lower cost graphical display equipment. By 1984, mass-market computer systems using graphical user interfaces were available; by the turn of the 21st century, text-mode operating systems were no longer a significant fraction of the personal computer market.

Applications

Generally, a computer user uses application software to carry out a specific task. System software supports applications and provides common services such as memory management, network connectivity and device drivers, all of which may be used by applications but are not directly of interest to the end user. A simplified analogy in the world of hardware would be the relationship of an electric light bulb (an application) to an electric power generation plant (a system):

the power plant merely generates electricity,

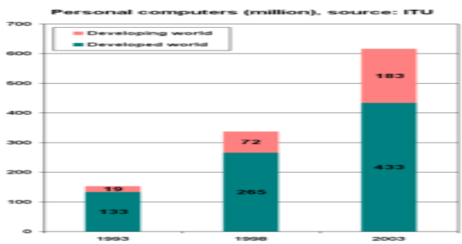
not itself of any real use until harnessed to an application like the electric light that performs a service that benefits the user.

Typical examples of software applications are word processors, spreadsheets, and media players. Multiple applications bundled together as a package are sometimes referred to as an application suite. Microsoft Office and LibreOffice, which bundle together a word processor, a spreadsheet, and several other discrete applications, are typical examples. The separate applications in a suite usually have a user interface that has some commonality making it easier for the user to learn and use each application. Often, they may have some capability to interact with each other in ways beneficial to the user; for example, a spreadsheet might be able to be embedded in a word processor document even though it had been created in the separate spreadsheet application.

End-user development tailors systems to meet the user's specific needs. User-written software include spreadsheet templates, word processor macros, scientific simulations, graphics and animation scripts; even email filters are a kind of user software. Users create this software themselves and often overlook how important it is.

Gaming

PC gaming is popular among the high-end PC market. According to an April 2018 market analysis done by Newzoo, PC gaming has fallen behind both console and mobile gaming in terms of market share sitting at a 24% share of the entire market. The market for PC gaming still continues to grow and is expected to generate $32.3 billion in revenue in the year 2021. PC gaming is at the forefront of competitive gaming, known as Esports with games such as ROBLOX and Minecraft leading the industry that is suspected to surpass a trillion dollars in revenue in 2019.



Personal computers worldwide in million distinguished by developed and developing world

In 2001, 125 million personal computers were shipped in comparison to 48,000 in 1977. More than 500 million personal computers were in use in 2002 and one billion personal computers had been sold worldwide from the mid-1970s up to this time. Of the latter figure, 75% were professional or work related, while the rest were sold for personal or home use. About 81.5% of personal computers shipped had been desktop computers, 16.4% laptops and 2.1% servers. The United States had received 38.8% (394 million) of the computers shipped, Europe 25% and 11.7% had gone to the Asia-Pacific region, the fastest-growing market as of 2002. The second billion was expected to be sold by 2008. Almost half of all households in Western Europe had a personal computer and a computer could be found in 40% of homes in United Kingdom, compared with only 13% in 1985.

The global personal computer shipments were 350.9 million units in 2010, 308.3 million units in 2009 and 302.2 million units in 2008. The shipments were 264 million units in the year 2007, according to iSuppli, up 11.2% from 239 million in 2006. In 2004, the global shipments were 183 million units, an 11.6% increase over 2003.

In 2003, 152.6 million computers were shipped, at an estimated value of $175 billion. In 2002, 136.7 million PCs were shipped, at an estimated value of $175 billion. In 2000, 140.2 million personal computers were shipped, at an estimated value of $226 billion. Worldwide shipments of personal computers surpassed the 100-million mark in 1999, growing to 113.5 million units from 93.3 million units in 1998. In 1999, Asia had 14.1 million units shipped.

As of June 2008, the number of personal computers in use worldwide hit one billion, while another billion is expected to be reached by 2014. Mature markets like the United States, Western Europe and Japan accounted for 58% of the worldwide installed PCs. The emerging markets were expected to double their installed PCs by 2012 and to take 70% of the second billion PCs. About 180 million computers (16% of the existing installed base) were expected to be replaced and 35 million to be dumped into landfill in 2008. The whole installed base grew 12% annually.

Based on International Data Corporation (IDC) data for Q2 2011, for the first time China surpassed US in PC shipments by 18.5 million and 17.7 million respectively. This trend reflects the rising of emerging markets as well as the relative stagnation of mature regions.

In the developed world, there has been a vendor tradition to keep adding functions to maintain high prices of personal computers. However, since the introduction of the One Laptop per Child foundation and its low-cost XO-1 laptop, the computing industry started to pursue the price too. Although introduced only one year earlier, there were 14 million netbooks sold in 2008. Besides the regular computer manufacturers, companies making especially rugged versions of computers have sprung up, offering alternatives for people operating their machines in extreme weather or environments.

In 2011, Deloitte consulting firm predicted that, smartphones and tablet computers as computing devices would surpass the PCs sales (as has happened since 2012). As of 2013, worldwide sales of PCs had begun to fall as many consumers moved to tablets and smartphones. Sales of 90.3 million units in the 4th quarter of 2012 represented a 4.9% decline from sales in the 4th quarter of 2011.

Global PC sales fell sharply in the first quarter of 2013, according to IDC data. The 14% year-over-year decline was the largest on record since the firm began tracking in 1994, and double what analysts had been expecting. The decline of Q2 2013 PC shipments marked the fifth straight quarter of falling sales. "This is horrific news for PCs," remarked an analyst. "It's all about mobile computing now. We have definitely reached the tipping point." Data from Gartner showed a similar decline for the same time period. China's Lenovo Group bucked the general trend as strong sales to first time buyers in the developing world allowed the company's sales to stay flat overall. Windows 8, which was designed to look similar to tablet/smartphone software, was cited as a contributing factor in the decline of new PC sales. "Unfortunately, it seems clear that the Windows 8 launch not only didn't provide a positive boost to the PC market, but appears to have slowed the market," said IDC Vice President Bob O'Donnell.

In August 2013, Credit Suisse published research findings that attributed around 75% of the operating profit share of the PC industry to Microsoft (operating system) and Intel (semiconductors). According to IDC, in 2013 PC shipments dropped by 9.8% as the greatest drop-ever in line with consumers trends to use mobile devices.

In the second quarter of 2018, PC sales grew for the first time since the first quarter of 2012. According to research firm

Gartner, the growth mainly came from the business market while the consumer market experienced decline.

Average selling price

Selling prices of personal computers steadily declined due to lower costs of production and manufacture, while the capabilities of computers increased. In 1975, an Altair kit sold for only around US$400, but required customers to solder components into circuit boards; peripherals required to interact with the system in alphanumeric form instead of blinking lights would add another $2,000, and the resultant system was only of use to hobbyists.

At their introduction in 1981, the US$1,795 price of the Osborne 1 and its competitor Kaypro was considered an attractive price point; these systems had text-only displays and only floppy disks for storage. By 1982, Michael Dell observed that a personal computer system selling at retail for about $3,000 US was made of components that cost the dealer about $600; typical gross margin on a computer unit was around $1,000. The total value of personal computer purchases in the US in 1983 was about $4 billion, comparable to total sales of pet food. By late 1998, the average selling price of personal computer systems in the United States had dropped below $1,000.

For Microsoft Windows systems, the average selling price (ASP) showed a decline in 2008/2009, possibly due to low-cost netbooks, drawing $569 for desktop computers and $689 for laptops at U.S. retail in August 2008. In 2009, ASP had further fallen to $533 for desktops and to $602 for notebooks by January and to $540 and $560 in February. According to research firm NPD, the average selling price of all Windows portable PCs has fallen from $659 in October 2008 to $519 in October 2009.

ENVIRONMENTAL IMPACT

External costs of environmental impact are not fully included in the selling price of personal computers.

Personal computers have become a large contributor to the 50 million tons of discarded electronic waste generated annually, according to the United Nations Environment Programme. To address the electronic waste issue affecting developing countries and the environment, extended producer responsibility (EPR) acts have been implemented in various countries and states. In the absence of comprehensive national legislation or regulation on the export and import of electronic waste, the Silicon Valley Toxics Coalition and BAN (Basel Action Network) teamed up with electronic recyclers in the US and Canada to create an e-steward program for the orderly disposal of electronic waste.

Some organizations oppose EPR regulation, and claim that manufacturers naturally move toward reduced material and energy use.

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THE USE OF THE INTERNET FOR EDUCATIONAL PURPOSES

The growth of the Internet in the world provides many opportunities to many people around the world in many different ways. When students are considered, the use of the Internet is mainly for social and entertainment purposes. However, it is very obvious that the Internet provides not only social connection and entertainment, but also academic and scientific information as well. Additionally, the Internet can be used as a tool to learn the latest news all around the world as well as getting any kind of information that serves different purposes such as learning more information about a hobby or health.

Therefore, it can be said that the Internet is the source of spreading information quickly to a large audience and of going beyond the limitation of time and space. In the light of the above information, it is vitally important to encourage students to use this invaluable source to get any kind of information they need in their academic studies. For the reasons mentioned above, the aim of this study is look at the students' use of Internet in their academic studies. The participants are around 150 English Preparatory School students in Eastern Mediterranean University.

These students have come from different countries in order to study at various departments in the university. The study is carried out in the Spring Semester of the Academic Year 2010-2011. © 2011 Published by Elsevier Ltd. Keywords: Internet, Education, Prep School, Academic Use of Internet 1. Introduction Since the emergence of the Internet, it has become an important medium of communication as well as a research and leisure tool. The reason is that it provides many opportunities to many people around the world in many different ways. Not only the Internet, but the other new digital technologies also took their places in the daily life.

The wide access to these technologies improves people’s lives and provides great opportunities. People have started to access any kind of information easily on the Internet and also use it for social, educational and entertainment nowadays kids do not like to use libraries or any kinds of real life resources but they can access these places online and benefit from them easily and quickly. Additionally, the Internet can be used as a tool to learn the latest news all around the world as well as getting any kind of information that serves different purposes such as learning more information about a hobby or health.

Therefore, it can be said that the Internet is the source of spreading information quickly to a large audience and of going beyond the limitation of time and space. Regarding students who are obviously accepted as passionate users of the Internet, the use of the Internet is mainly for social and entertainment purposes since the Internet revolution is not just limited to finding information but also bringing people together. However, it is very obvious that the Internet provides not only social connection and entertainment, but also academic and scientific information as well.

Thus, it is vitally important to encourage students to use this invaluable source to get any kind of information they need in their academic studies because the development of the Internet would be meaningless if it is not used appropriately in education. Therefore, new digital technologies have been widely involved in higher education institutions as well as other sections of the education system all over the world (Park and Biddix, 2008). In addition, Internet use has the potential to improve the quality of education (Ciglaric et al., 1998; Charp, 2000; Laurillard, 1992).

Charp (2000) also stated that the Internet brought numerous positive changes to teachers and instructors. According to Dryli & Kinnaman (1996), the Internet enables students to find information as well as allowing them to think critically and creatively, to become collaborative and cooperative workers and to solve problems. Besides the children of the new technological era that we live in today are influenced by the new literacies and pedagogies, it is important to consider the fact that “the capability to use online and offline databases as well as web search-engines effectively is paramount in cyberspace” (Nentwich, 2003). Today’s students, future scholars and knowledge workers, are required to have the ability to reach the correct information and they need to be able to get the necessary and accurate information amongst unlimited bits of information. “Finding the right information is only one side of the core business of academics.

As Nentwich (2003) stated the other side is organizing, structuring and evaluating the information space. At this point, it is a necessity to mention the three important Internet literacies defined by Burgess (2006):

1. **Critical Literacy** – a deep, socially contextualized, and informed understanding of the Internet;
2. **Creative Literacy** – The ability to experiment with the Internet in order to create and absorbing information;
3. **Network Literacy** – The ability and the impulse to effectively and ethically manipulate a range of the Internet technologies to communicate and collaboratively construct and share knowledge (Burgess, 2006).

When the previous studies on the Internet are examined, it can clearly be seen that the majority is focused on the differences between learning outcomes of the courses taught with using the Internet and the courses taught in the traditional ways (Benoit et. al., 2006). However, it is important to be aware of the fact that students are not inactive receivers during the transmission of knowledge via the Internet. The efficacy of students and looking at the picture through their eyes is vitally important in the way to reach success. As a result of the reasons supported by the literature and mentioned above, the aim of this study is look at the students' use of the Internet in their academic studies.

Methods

1 Participants

The participants of the study were 100 students who studied in different levels at English Preparatory School, Eastern Mediterranean University during Spring Semester of 2010 – 2011. In the study there were 80 male and 20 female students. Nearly half of them were at the age of 19 and 20 and 32% of them were 21 and above. 50 of them were from Turkey, 17 of them were from North Cyprus, 15 of them were from Azerbaijan, 8 of them from Iran and there were 9 participants from other countries.

2 Instrument

In the study an adapted version of the "Self-Efficacy Scale on Educational Use of the Internet" which was prepared by Sahin (2009) was used as the instrument.

The ready scale was prepared in Turkish and there were 608 Nazan Dogruer et al. / Procedia - Social and Behavioral Sciences 28 (2011) 606 – 611 students who did not know

Turkish in the population so the English version of the scale was prepared for the study by the researchers.

During the preparation of the English version, one of the researchers translated it into English and the English version of the scale was proof-read and then re-translated into Turkish in order to see if English and Turkish versions of the scale were in parallel.

In the first part of the instrument, there were three items which were designed by the researchers to obtain background information of the participants.

The “Self-efficacy Scale on Educational Use of the Internet” was used in the second part of the instrument. In the scale there were positive statements with five-likert choices as ‘I’m insufficient’, ‘I’m a little sufficient’, ‘I’m sufficient’, ‘I’m quite sufficient’ and ‘I’m completely sufficient’.

Participants were asked to choose the best alternative that described them for each statement.

After conducting the research, the reliability value of the scale was calculated as 0.966 which is statistically accepted as considerably high.

3 Procedure

After the necessary permissions were taken from the Administration of the English Preparatory School, the researchers approached the class teachers, explained the instrument briefly and asked them to help their students mark their choices on the optic answer sheet. When the instruments were collected, the optic answer sheets were processed and then PASW Statistics 18 was used in order to examine the data. Participants' responds to the scale were computed in order to obtain total scores of them. Then the each item's frequencies were examined in order to identify in which areas participants felt themselves confident.

Results

In this section the overall and item-based results of the participants were given. First of all, participants' selfefficacy on using the Internet as an educational tool was examined and then detail examination of the items were done in order to find out in which areas the participants felt themselves sufficient enough.

Analysis of the Scale

In this section, it was aimed to examine the areas that students felt themselves sufficient and insufficient by analyzing the items in the scale in detail. Therefore, according to the responses of the participants, the percentages of each alternative were calculated and the items were reordered from top to down.

Areas That Students

Feel Sufficient In this section it was aimed to find out the areas that the participants felt themselves sufficient enough while using the Internet for educational purposes. Table 3 shows the areas that most of the participants felt themselves sufficient. As it can be clearly seen in Table 3, most of the participants (80%) declared that they use search engines on the Internet and as they were preparatory school students who have been learning English, they stated that they used e-dictionaries on the Internet with a high percentage (67%). As EMU English Preparatory School instructors encourage their students to create and join the Facebook group of their classes in order to discuss class-related topics, considerable amount of participants (65%) confirmed that they used the Internet to talk about school subjects and homework. Also, students are expected to prepare an oral presentation as part of their assessments so the majority asserted that they used the Internet to find source of information, to download pictures or photos, and to do research. They also used the Internet for translation as most of them did not feel themselves confident enough to write academic writings in English.

AREAS THAT STUDENTS FEEL SUFFICIENT

In general it was clear that the majority of the students believed they can use the Internet as an educational tool. Only a very small amount of participants stated that they were not able to use it for educational purposes, which is very promising for the future. There were certain areas that students felt comfortable while using the Internet such as the search engines on the Internet, which is easily and efficiently used and preferred by 80% of the participants in this study. Also, they stated that they used social websites to share knowledge and talk about school subjects. They also claimed that they could easily use the Internet to find sources of information, download necessary files and pictures and so on.

Moreover, the participants stated that they used e-dictionaries, e-encyclopedias and translation tools to help them write their homework and do their projects. The only problematic areas which seemed the participants are not very good at were blogs, wikis and e-learning portals and the reason might be neither students nor teachers could really cope with them efficiently and appropriately. Both groups are not very familiar with these Internet options as well as with the educational journals and database programs.

Furthermore, educational journals could be another issue to be considered. As the participants of this study were preparatory school students, they might have not needed to use educational journals in order to be successful in their academic studies or fulfill their academic tasks. Therefore, it is vital and important to provide opportunities to students to learn these areas which are indispensable tools in today's academic and social life.

As a further study, it could be a good idea to conduct a similar study after a course which aims to familiarize students with these tools. In the study, the participants of the course could be asked to choose the best items that describe them in the scale both at the beginning and at the end of the course in order to see whether there are any differences in the efficacy level of the students.

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SUBJECT OF ICT COURSE İN EDUCATİON

İCT IN EDUCATION CURRICULUM FOR STUDENTS

The term Information and Communication Technology (ICT) is a broad and comprehensive expression. It is not restricted to the computers or the internet alone. It ranges from the use of FM radio to satellite for communication (ANDERSON 2002). Opines that ICTs are the fundamental building blocks of the present day society. The contemporary society is highly influenced by ICTs in every aspect of life, including education. The effects are experienced more in the field of education since it has the potential for teachers to transform the teaching methodology to meet individual needs (Yusuf 2005).

Today, schools are under pressure to adapt to this technological innovation. ICT provide remarkable opportunities for developing countries to enrich their educational system since it can help in acquiring and assimilating knowledge (L.Tinio 2002). The importance of ICT has been recognized by educational institutions worldwide. Asserts that ICT has influenced the way people function today, both personally and professionally, which demands change in the educational arena. Schools that train their students in yesterday's skills and outdated technologies are not meeting the needs of tomorrow's world. Such children will not fit into tomorrow's professional requirements. According to Telecommunications Standardization Sector(ITU), ICTs can act as a facilitator in promoting learning skills, when implemented and utilized effectively. Effective use of ICT is crucial to countries that are progressing towards information or knowledge-based society (Watson 2001).

ICT is a pivotal tool in spreading quality education. According to Kofi Annan, the former General Secretary of the United Nations, ICT helps to achieve the aim of Universal

Primary Education by 2015; since it can take learning beyond the four walls of the classroom. This implies the vital role played by ICT in the educational sector.

The application of information and communication technologies in education has been divided into two main categories:

1. ICTs for Education and ICTs in Education. ICT for education identifies the development of information and communications technology especially for teaching-learning purposes while the ICTs in education includes the adoption of basic elements of information and communication technologies in the teaching-learning process.
2. ICT provides great flexibility in education to ensure that learners are able to access knowledge anytime and from anywhere. It also affects the way knowledge is imparted and how students learn. Research undertaken worldwide has confirmed that ICT can help to improve student learning by providing better instructional

techniques (Lemke and Coughlin 1998; Davis and Tearle 1999).

Guided by the National Policy on ICT in School Education , the curriculum for students is designed to promote creativity, problem solving, and introduce students to the world of information and communication technologies with the specific purpose of widening their horizons and better informing them of choices in their career pursuits. In particular, the curriculum focuses on training the student to working with a variety of resources; learning to critically appraise information and resources; and making safe, productive, ethical and legal use of these resources a habit.

Students are also introduced to ICT outside the classroom context. Their curiosity and desire to learn will prompt them to more intensely participate in ICT activities. While introduction to social networks and blogging would become inevitable, making them aware of cyber bullying or other means of violating their rights should become an essential part of the training. While experimenting with hard and software the range of learning is very high. Channelising these tendencies and co-opting them into the teaching-learning process can help teachers create able support to the ICT system in the school.

The impact of ICT on the overall development of the personality can be extremely significant. In particular its effect on the improvement of communication skills is treated as a central goal of the ICT curriculum. Language barriers and isolation can deny students access to the wide range of digital information and resources. Physically challenged particularly the visually impaired and auditory impaired needs additional support. Heightened awareness on the part of the system will help address these students’ problems of access.

Based on the availability of ICT infrastructure and the provisioning of an ICT class in the timetable, different schools or Boards of School Education can exercise the choice to begin the ICT programme with any appropriate class, but ensure that every student completes the advanced stage outlined in the National Policy on ICT in School Education before completing schooling.

This curriculum is recommended for use with students of classes 6-12. It should not be used at the primary stage (classes 1 to 5). A structured ICT programme at the primary stage is not desirable and can be counterproductive.

The ICT curriculum for students is also conceived as an important vehicle for the realisation of the goals of the National

Curriculum Framework. It attempts to introduce students to a dynamic, immensely popular field, exposing them to a wide range of information and resources, motivating them to explore and participate in. It can not only support learning, but also introduce them to diverse activities which challenge their intellect and imagination.

To this end, the curriculum is organised into four strands:

1. Connecting with the world
2. Connecting with each other
3. Creating with ICT
4. Interacting with ICT

The scope of these strands remains the same as that for teachers.

In terms of activities however, the syllabus articulates content differently, taking into consideration the age profile of students, their unique needs and the objective of preparing them for their future.

The ICT curriculum broadly attempts to equip students with an ability to negotiate a range of devices, tools, application, information and resources.

The course is offered in chunks of three periods in a week, which include one teacher led session and two hands on sessions.

The teacher led session aims to demonstrate techniques and processes and prevent a context to the learning. Following this, students engage themselves with activities which are designed to provide adequate hands on experience.

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QUESTIONS LIST

1. What about is mentioned «The term Information and Communication Technology (ICT)»?
2. Definition İCT by ANDERSON 2002?
3. Definition İCT by Yusuf 2005?
4. Definition İCT by L.Tinio 2002?
5. Definition İCT by Watson 2001?
6. How many categories ICT has been divided in education?

7. What kind of ability is designed by the curriculum for students ?

8. How mane standarts can be organized the curriculum into ?

THE MAİN GOALS AND OBJECTİVES OF ICT İN EDUCATİON.

Objectives:

1.After the ICT intervention games, the students will be able to:

2.Create digital art and textual materials

3.Use e-resources for learning of curricular subjects

4.Interact with ICT devices confidently

5.Practise safe, legal and ethical means of using ICT

6.Develop digital literacy skills that will enable them to function as discerning students in an increasingly digital society

7.Access various tools and applications for learning and skill development

8.Operate a variety of hardware and software independently and troubleshoot common problems

9.Use the ICT facility with care, ensuring the safety of themselves, others and the equipment

10. Create a variety of digital products using appropriate tools and applications and saving, storing and managing digital resources

11. Practise safe, legal and ethical means of using ICT

The 21st century is already the age of knowledge, the knowledge society and the educational age. The educational industry will be the industry of the 21st century. It is only natural that new technologies, ICT (Information and Communication Technology) above all, are in the focus of those who are contemplating the novelties in education. ICT has brought a range of new terms in the education like: e-learning, distance education, virtual classrooms, etc. While new terminology is being defined and redefined, hundreds of pioneers experiment with the usage of ICT in education.

The strategists of education, politicians and decision makers on the national and international level are prophesying, proposing, planning and talking about major benefits from ICT implementation in education. The most important benefit from ICT in education it is hoped for is improved learning outcomes.

It would provide necessary skilled workforce for the knowledge society while boosting cost/benefit ratio. No less important is hope to speed up learning process making it in average much faster than today.

Democracy would get to its full potential by democratization of learning, lowering all sorts of boundaries between students and knowledge while bringing knowledge to all students and unlimited number of them. This hope is combined with already an urban legend that ICT will make learning and teaching much cheaper. Finally, while quality learning does require substantial effort from students and teachers, the process itself could be much easier and more pleasant.

The Vision

Fueled with these hopes and based on proliferating use of ICT in almost every aspect of modern life, almost universally shared vision is created. This vision believes that overall human knowledge (already mostly is, but certainly) soon will be fully digital and available to any student globally for whatever purpose. The world where a student is restricted to locally available teacher is the past and we see the world in which student and teacher are globally matched and paired for a specific learning activity based on desired outcome, psychology, timing, cost, and multiple other factors. It is envisioned that students will learn anytime when their need and ability meet, at the pace that best suites them. Finally, it is clearly seen that education process will be freed from non-educational activities like: administration, support, organization, etc. They will be minimized, automated, reprogrammed, asynchronous and delegated.

The Reality

While an army of researchers are seeking technical and organizational solutions, while pioneers all over the world already for more than a decade experiment "in vitro" implementing those solutions and while politicians talk and beehive as if they single handedly created the vision and bore solutions for it and as if the vision is already implemented and realized, the reality is quite different.

ICT is still far from the mainstream of education. It is predominantly in hands of pioneers and early adopters, still on the margins of early majority. The furthest most "mainstream educators" came is to publish "digital photocopies" of their educational materials. They simply switched media leaving materials in the form of “paper age”. Even worse, e-learning is still mostly illegal.

Not that someone will be prosecuted for doing it, but in the sense that only minority of educational institutions recognize e-learning as their regular way of teaching and learning and even smaller number makes it their strategy and priority.

The whole initiative is operating in an organizational vacuum in most educational institutions, globally.

The expectations form ICT leverage are greatly exaggerated while not being properly planned for and without or with only symbolic financing.

The key problem are missing and unassigned responsibilities in the envisioned change process.

The Forces

Thus those visions are nothing more than dreams tending to become illusions. So, what can be done to change that situation? The first thing to look at are the forces to change. Without a change driver there won’t be any change. The forces in any process come from the customer, internally and from the environment .

The ultimate customer of the educational industry is the one who uses skilled professionals: the industry. The industry is already demanding well educated highly skilled professionals. There is increased demand for customized education targeted at specific subset of knowledge or tailored for a specific project. Another demand from industry is globally standardized certification of knowledge and skills.

Internal change forces are students and teachers. Because of the industry demands, students need customized education, now and fast and they do not want to waste time on any kind of overhead: administrative, organizational or any other. Teachers want to reach every student globally available in order to maximize the gain from their investment in designing educational materials, tools and processes. They too want to reduce overhead in order to boost their own productivity.

The globalization process creates pressure from the environment creating competition where there wasn’t any and bringing it from sources unknown till now. For example, globally available virtual labs and remote labs compete with physical facilities at local school. Competitors are no longer only other local or national schools not even well established and recognized schools from the world.

Competition today comes from countries and institutions one barely heard of or even from industrial education facilities whose educational certificates are globally recognized and demanded (Cisco, Microsoft, LPI, ECDL, …). Finally, the process of decoupling teaching from certification (ECDL, LPI, …) is a force in itself that will irreversibly change the landscape of traditional educational institution we all are familiar with.

The Aim

Leveraging the forces available and bearing in mind the vision, a realistic aim should be agreed upon. An aim on which change agents, implementers and all other players could keep an eye while embarking on this exciting journey of fundamentally changing the activity which makes humans essentially different from all other species: learning.

This aim could be surprisingly simple. It is to move ICT from labs, experimental institutions and pilot projects to every days practice in a broad number of activities in majority of schools.

The Way

Using this aim as an orientation point, a way towards it needs to be designed. The way is a stepwise process to be followed both globally and in each segment of the way or specific activity. It needs to:

- define objectives,
- for each objective identify: change drivers, players, resources, outcomes, leaders,
- set the infrastructure,
- plan,
- publicize.

The first step is to define objectives. Objectives are clearly defined realistic goals to be accomplished. In the next step, for each objective change drivers, players, available and needed resources as well as measurable expected outcomes need to be identified. Leaders are those who initiate and sustain the change process.

The third step calls for setting the infrastructure. It encompasses everything that will be used in the change process or that will support it: strategies, materials, equipment, money, time, people, education, consultants, … With infrastructure set, a change plan consisting of sets of well documented procedures needs to be designed. Finally, the players in the change process need to become informed and familiarized with all this through extensive and continuous process of publicizing.

The Objectives

This paper's scope is to propose one possible set of objectives that could realize above defined aim. For each objective a set of applications, change drivers, requirements and possible leaders will be identified. Education processes differ among themselves because of the subject of learning, required learning outcomes, previous knowledge, learning styles, culture, industry and many other factors. On the other hand, ICT can be used in a variety of ways in any traditional or new activity.

These two factors combined derive numerous activities in educational process in which ICT is or can be implemented. In order to streamline them and to try to identify some common points and shared resources, it is proposed to group them in three sets of objectives:

- Support functions: administrative, technical and supportive functions ,
- Learning assistance: assistance and support for learning and teaching,
- New learning: new teaching and learning methods, techniques and tools.

Support functions

Support functions are all those administrative, technical and supportive functions that are (considered to be) necessary in today's educational processes but which do not increase the knowledge or skills of students by themselves. In particular they are: enrolment to courses and programs, certification (a formal and administrative process as opposed to knowledge verification) and payment.

They are also:

1. scheduling of classes,
2. exercises and exams;
3. attendance granting and monitoring;
4. resource allocation and usage monitoring and billing.

Surveys, statistics and reports belong here, too. Supplemental functions are provision and usage of libraries and info services, counseling and student assistance.

Finally, the mere physical presence at the premises of a school is a support function, as well, Today, a substantial amount of student's and teacher's time is used for those functions. By intensive, extensive and proper use if ICT all mentioned functions can be reduced, automated, asynchronized or avoided at all.

The goals should be to avoid (the need for) physical presence for all administrative activities and for all those learning activities where possible. The data which a user (student or teacher) enters into the system should be available system wide and should never be entered again.

Every function that can be described by rules and programmed should be performed by computers, automatically, not requiring human effort. The communication among all players in the educational system should be available on-line 24 hours a day 365 days a year using the variety of communication techniques (phone, Internet …) preferably asynchronous ones: SMS, IM, e-mail.

This means that administrative information systems, automated information systems and digital libraries should be built. Teleconferencing should be routinely used. Virtual communities need to be established providing legal assistance, support groups etc. Finally, virtual and remote labs should be designed. All the technologies exist, applications have been tested world wide and concepts proved in practice. So, what needs to be done in order to implement them on the broader scale?

The change drivers fall in two categories:

1. financial pressure
2. market competition.

The need for administrative cost reduction and efficient resource usage make financial pressure on school administrations. Market competition in form of increased offer from other educational institutions and new players from the industry will result in increased demand from both students and teachers to reduce non-educational burden on their time.

In order for those changes to take place, certain requirements need to be met: educational institutions need to be (at least partially) cost based instead of fixed budget, students need to be empowered and regulational framework in place supporting remote work and education in general. Finally, the leaders of change need to be identified. In this case these are students, their organizations and leaders and leaders from administration (school, local, or national).

Learning assistance

Learning assistance are all those functions that provide assistance and support for learning and teaching. They are closely related or bound to learning content and process but do not directly increase student's knowledge or skills in the learning domain. They are comprised of resources and systems that make learning and teaching faster, easier, better focused, broader and deeper thus enhancing the understanding and mastering domain knowledge and skills. They are also systems that continuously improve teacher's competences as well as student's knowledge and skills outside (but in "neighborhood") of the learning domain.

The goals within this objective are to provide students with all necessary and desired information and knowledge and to do so in digital form suitable for any type of processing and manipulation they deem desirable. A goal is also to further physically and temporally decouple student from any other individual, resource or process required or desired in learning. Assumed goal is that all necessary resources are available to a student as well as training and support to efficiently use them. An important resource in learning process are centers of excellence: points of referral when in doubt or need for clarification and assistance.

These goals can be accomplished by digitizing all existing learning and teaching materials and making them available online, by establishing and opening digital libraries and opening all relevant digital collections and libraries world-wide to students while learning.

Archives of student's results from previous generations as well as their questions and answers to them are invaluable source and aid in learning process. E-mail communication with teachers and other students, virtual (global) working groups, distance asynchronous teaching, live streaming and recordings of lectures, exercises and events greatly enhance and simplify learning process.

Computers, communications and SW tools per se but also as means to access and use other resources should be treated as resources and readily, omni presently available to students. Training and assistance for their usage are natural part of those resources.

In order to create described learning assistance, change forces can come from three sources. Students will demand them as market competition increases and competitors start creating their own market advantage offering such assistance. Professional educational standards could come from teachers professional associations and education industry as the changing force. Educational community (such as university) could create “service level” requirements within themselves thus creating internal change force. Obvious but serious obstacles in this process area associated cost and huge effort required from all involved in providing education and traditional inertia of large systems. In order for these changing forces to succeed there are requirements to be fulfilled. Above all it is necessity to honestly, substantially recognize the (importance of) teaching quality and achievement.

Currently there are only few instances where a regulation would prevent development of learning by means of ICT, but significant changes in regulation are a must in order to foster it. Market competition of education providers is single most important factor that needs to be established in order to “wake up giants”.

When all this is set, the infrastructure that will support e-learning needs to be in place, too. Large financial investment is inevitable in every educational system. The final question is: who can lead the change? In part that can be students demanding resources. Majority of burden still lies on educational authorities and governance. However, teachers and their associations cannot avoid their responsibility in this change .

New learning

New learning is a joint name for new methods, techniques and tools in teaching and learning that substantially change the outcomes, the way and the experience of learning. They do so in the way which would be impossible, impractical or prohibitively expensive without the use of ICT.

Since this is a very innovative field of ICT leverage it is difficult to set fixed goals, but on the general terms it is about full adjustment of learning process to needs and abilities of the student. It is focused on understanding and mastering knowledge modules of sustainable importance.

Above all it is about putting full control of learning process in student's hands, making learning process as transparent as possible with ample reference points enabling students to measure their progress, asses acquired skills and knowledge and find their way forward in every learning situation.

These goals can be accomplished through ICT implementation in several ways. One of most innovative ways is by means of virtual laboratories in which students can perform endless experiments at no additional cost, dangerous or unethical (on simulations of human body) experiments, impossible experiments (temperatures close to absolute zero or no-gravitation environment) or experiments with compressed or elongated time line. Virtual working groups and faculty staff would add to student's ability to truly understand and grasp learning concepts.

Self examination tools are those that will provide students with orientation points for their own path and milestones along it. Self paced integrated adaptive learning materials are the ultimate goal. They are as close to the real teacher silicone technology will ever get. They will liberate teachers from tedious and routine work and concentrate their skills and energy to providing teaching, mentoring and coaching only human can.

Simultaneously, students will be able to learn in the way best suits them, aiming to the goals tailored to their needs, in the process optimized to their abilities while keeping the control in their own hands.

The major driver that will force change in the learning process itself is market competition. Once students experience new, enhanced learning they will demand it from all educators. Since the major burden of changing the learning process is on teachers, market competition will result in pressure from educational employers who will require teachers to improve and develop the learning process.

In addition, teacher’s professional associations may come forward with new set of professional teaching standards which could serve as an auxiliary change driver. As with other objectives, market competition should not only be waited for but should be proactively created by national governments, educational communities, international associations and industry at large. Strong recognition of quality (in) teaching is a must for the changes to become sustainable.

It has to be understood that new learning requires more effort on side of teachers and students likewise, plenty of time and a lot of money. In addition, since teachers and students alike are walking on a completely new path they need strong support. In such an innovative process it is very difficult to precisely plan for required infrastructure and even more difficult to optimize its use.

Therefore a state-of-the-art, abundant infrastructure needs to be provided to all players. Crucial point to understand is that innovative teachers are pioneers in this process, not leaders. Leaders can be only those who can (inter)connect ideas, pilots and new achievements, obtain resources and start the change process. In general, those are decision makers at the highest level .

Conclusion

Proposed set of objectives, goals, drivers, requirements and leaders is not the only one possible but could be used as an orientation point or guiding principle to design a similar one for the educational change desired.

It is important to identify, define and design all components and put them in operation because they are all crucial. For example, even ample resources and detailed plan will bear no results if they are missing a change force or are trying to engage the wrong one. Similarly, without the proper leader there will be no sustainability and no focus in the process and thus desired results cannot be achieved.

However, if all elements are in place and are applied over the appropriate period of time, they will result in expected outcomes. Leading authors on change in educational systems agree that the major changing force are teachers. Students have very important role, too. All others are “merely” in a support function but their role is therefore not less important and their responsibility cannot be circumvented. Indeed, support functions in education like decision makers, regulators and financiers are those with the major responsibility to design the change process properly and keep it in motion.

It is also important to increase the speed of learning and the provision of equal possibilities for everyone. Despite the fact that a qualitative learning requires making big effort from the students and the lecturers by using ICT the process itself could become more enjoyable and easier . Despite the great expectations, remarkable effort and even more remarkable investments and expenses the ICT usage for better results is still a problematic question. ...

The theoretical basis of the research is the Pale's division of ICT usage in education system and there are three categories: administrative, technical and other support functions for education, the support for the learning and teaching processes; as well as completely new methods, techniques and instruments for the learning and teaching processes. ...

If not ICT the process would be very expensive and not practical at all. It includes changing the study process so that it fits the student's needs and wants and we have to focus on the understanding and the long-term knowledge module development . The new learning could be carried out in several ways. ...

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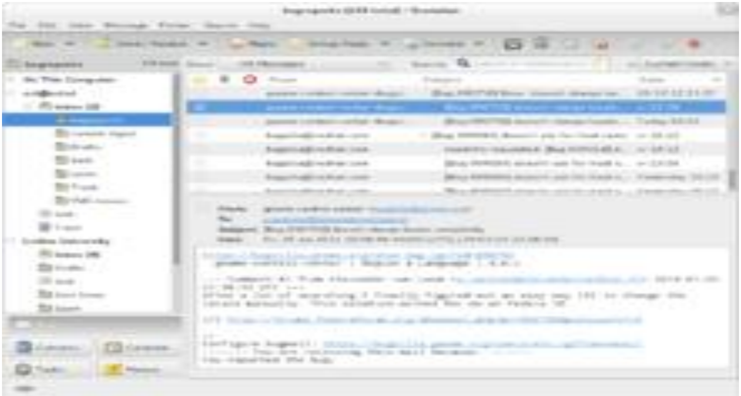
EMAIL

"Inbox" redirects here. For the discontinued Google product, see Inbox by Gmail.



This screenshot shows the "Inbox" page of an email client, where users can see new emails and take actions, such as reading, deleting, saving, or responding to these messages.

The at sign, a part of every SMTP email address

Electronic mail (**email** or **e-mail**) is a method of exchanging messages ("mail") between people using electronic devices. Invented by Ray Tomlinson, email first entered limited use in the 1960s and by the mid-1970s had taken the form now recognized as email. Email operates across computer networks, which today is primarily the Internet. Some early email systems required the author and the recipient to both be online at the same time, in common with instant messaging. Today's email systems are based on a store-and-forward model.

Email servers accept, forward, deliver, and store messages. Neither the users nor their computers are required to be online simultaneously; they need to connect only briefly, typically to a mail server or a webmail interface for as long as it takes to send or receive messages or to download it.

Originally an ASCII text-only communications medium, Internet email was extended by Multipurpose Internet Mail Extensions (MIME) to carry text in other character sets and multimedia content attachments. International email, with internationalized email addresses using UTF-8, has been standardized, but as of 2017 it has not been widely adopted.

The history of modern Internet email services reaches back to the early ARPANET, with standards for encoding email messages published as early as 1973 (RFC 561). An email message sent in the early 1970s looks very similar to a basic email sent today.

Historically, the term electronic mail was used generically for any electronic document transmission. For example, several writers in the early 1970s used the term to refer to fax document transmission. As a result, it is difficult to find the first citation for the use of the term with the more specific meaning it has today. Electronic mail has been most commonly called email or e-mail since around 1993, but several variations of the spelling have been used:

- email is now the most common form used, and recommended by style guides. It is the form required by IETF Requests for Comments (RFC) and working groups. This spelling also appears in most dictionaries.
- e-mail is the form that was favored in edited, published American English and British English writing as reflected in the Corpus of Contemporary American English data, but is falling out of favor in some style guides.
- mail was the form used in the original protocol standard, RFC 524. The service is referred to as mail, and a single piece of electronic mail is called a message.
- EMail is a traditional form that has been used in RFCs for the "Author's Address" and is expressly required "for historical reasons".

- E-mail is sometimes used, capitalizing the initial E as in similar abbreviations like E-piano, E-guitar, A-bomb, and H-bomb.

An Internet e-mail consists of an envelope and content; the content in turn consists of a header and a body.

Origin

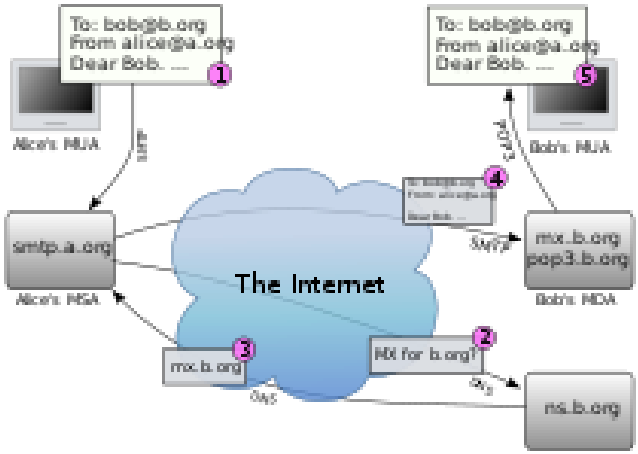
Computer-based mail and messaging became possible with the advent of time-sharing computers in the early 1960s, and informal methods of using shared files to pass messages were soon expanded into the first mail systems.

Most developers of early mainframes and minicomputers developed similar, but generally incompatible, mail applications. Over time, a complex web of gateways and routing systems linked many of them. Many US universities were part of the ARPANET (created in the late 1960s), which aimed at software portability between its systems. In 1971 the first ARPANET network email was sent, introducing the now-familiar address syntax with the '@' symbol designating the user's system address. The Simple Mail Transfer Protocol (SMTP) protocol was introduced in 1981.

For a time in the late 1980s and early 1990s, it seemed likely that either a proprietary commercial system or the X.400 email system, part of the Government Open Systems Interconnection Profile (GOSIP), would predominate. However, once the final restrictions on carrying commercial traffic over the Internet ended in 1995, a combination of factors made the current Internet suite of SMTP, POP3 and IMAP email protocols the standard.

Operation

The diagram to the right shows a typical sequence of events that takes place when sender Alice transmits a message using a mail user agent (MUA) addressed to the email address of the recipient.



Email operation

1. The MUA formats the message in email format and uses the submission protocol, a profile of the Simple Mail Transfer Protocol (SMTP), to send the message content to the local mail submission agent (MSA), in this case smtp.a.org.

2. The MSA determines the destination address provided in the SMTP protocol (not from the message header) — in this case, bob@b.org — which is a fully qualified domain address (FQDA). The part before the @ sign is the local part of the address, often the username of the recipient, and the part after the @

sign is a domain name. The MSA resolves a domain name to determine the fully qualified domain name of the mail server in the Domain Name System (DNS).

3. The DNS server for the domain b.org (ns.b.org) responds with any MX records listing the mail exchange servers for that domain, in this case mx.b.org, a message transfer agent (MTA) server run by the recipient's ISP.

4. smtp.a.org sends the message to mx.b.org using SMTP. This server may need to forward the message to other MTAs before the message reaches the final message delivery agent (MDA).

5. The MDA delivers it to the mailbox of user bob.

6. Bob's MUA picks up the message using either the Post Office Protocol (POP3) or the Internet Message Access Protocol (IMAP).

In addition to this example, alternatives and complications exist in the email system:

- Alice or Bob may use a client connected to a corporate email system, such as IBM Lotus Notes or Microsoft Exchange. These systems often have their own internal email format and their clients typically communicate with the email server using a vendor-specific, proprietary protocol. The server sends or receives email via the Internet through the product's Internet mail gateway which also does any necessary reformatting. If Alice and Bob work for the same company, the entire transaction may happen completely within a single corporate email system.

- Alice may not have an MUA on her computer but instead may connect to a webmail service.
- Alice's computer may run its own MTA, so avoiding the transfer at step 1.
- Bob may pick up his email in many ways, for example logging into mx.b.org and reading it directly, or by using a webmail service.
- Domains usually have several mail exchange servers so that they can continue to accept mail even if the primary is not available.

Many MTAs used to accept messages for any recipient on the Internet and do their best to deliver them. Such MTAs are called open mail relays. This was very important in the early days of the Internet when network connections were unreliable. However, this mechanism proved to be exploitable by originators of unsolicited bulk email and as a consequence open mail relays have become rare, and many MTAs do not accept messages from open mail relays.

Message format

The basic Internet message format used for email, is now defined by RFC 5322, with encoding of non-ASCII data and multimedia content attachments being defined in RFC 2045 through RFC 2049, collectively called Multipurpose Internet Mail Extensions or MIME.

The extensions in International email apply only to email. RFC 5322 replaced the earlier RFC 2822 in 2008, and in turn RFC 2822 in 2001 replaced RFC 822 – which had been the standard for Internet email for nearly 20 years. Published in 1982, RFC 822 was based on the earlier RFC 733 for the ARPANET.

Internet email messages consist of two major sections, the message header, and the message body, collectively known as content. The header is structured into fields such as From, To, CC, Subject, Date, and other information about the email. In the process of transporting email messages between systems, SMTP communicates delivery parameters and information using message header fields. The body contains the message, as unstructured text, sometimes containing a signature block at the end. The header is separated from the body by a blank line.

Message header

RFC 5322 specifies the syntax of the email header. Each email message has a header (the "header section" of the message, according to the specification), comprising a number of fields ("header fields"). Each field has a name ("field name" or "header field name"), which is followed by the separator character ":", and a value ("field body" or "header field body").

Each field name must start in the first character of a new line in the header section and begin with a non-whitespace printable character. It ends with the separator character ":". The separator is then followed by the field value (the "field body"). The value can continue onto subsequent lines if those lines have space or tab as their first character.

Field names and, without SMTPUTF8, field bodies are restricted to 7-bit ASCII characters. Some non-ASCII values may be represented using MIME encoded words.

Header fields

Email header fields can be multi-line, with each line recommended to be no more than 78 characters, although the technical limit is 998 characters. Header fields defined by RFC

5322 contain only US-ASCII characters; for encoding characters in other sets, a syntax specified in RFC 2047 can be used.

Recently the IETF EAI working group has defined some standards track extensions, replacing previous experimental extensions, to allow UTF-8 encoded Unicode characters to be used within the header. In particular, this allows email addresses to use non-ASCII characters. Such addresses are supported by Google and Microsoft products, and promoted by some governments.

The message header must include at least the following fields:

- **From:** The email address, and optionally the name of the author(s). In many email clients not changeable except through changing account settings.
- **Date**: The local time and date when the message was written. Like the From: field, many email clients fill this in automatically when sending. The recipient's client may then display the time in the format and time zone local to them.

RFC 3864 describes registration procedures for message header fields at the IANA; it provides for permanent and provisional field names, including also fields defined for

MIME, netnews, and HTTP, and referencing relevant RFCs. Common header fields for email include:

- **To**: The email address(es), and optionally name(s) of the message's recipient(s). Indicates primary recipients (multiple allowed), for secondary recipients see Cc: and Bcc: below.
- **Subject:** A brief summary of the topic of the message. Certain abbreviations are commonly used in the subject, including "RE:" and "FW:".
- **Cc: Carbon copy**; Many email clients will mark email in one's inbox differently depending on whether they are in the To: or Cc: list.
- **Bcc: Blind carbon copy**; addresses are usually only specified during SMTP delivery, and not usually listed in the message header.
- **Content-Type**: Information about how the message is to be displayed, usually a MIME type.
- **Precedence:** commonly with values "bulk", "junk", or "list"; used to indicate that automated "vacation" or "out of office" responses should not be returned for this mail, e.g. to prevent vacation notices from being sent to all other subscribers of a mailing list.

Send mail uses this field to affect prioritization of queued email, with "Precedence: special-delivery" messages delivered sooner. With modern high-bandwidth networks, delivery priority is less of an issue than it once was. Microsoft Exchange respects a fine-grained automatic response suppression mechanism, the X-Auto-Response-Suppress field.

- **Message-ID:** Also an automatically generated field; used to prevent multiple deliveries and for reference in In-Reply-To: (see below).
- **In-Reply-To**: Message-ID of the message that this is a reply to. Used to link related messages together. This field only applies to reply messages.
- **References**: Message-ID of the message that this is a reply to, and the message-id of the message the previous reply was a reply to, etc.
- **Reply-To:** Address that should be used to reply to the message.
- **Sender:** Address of the actual sender acting on behalf of the author listed in the From: field (secretary, list manager, etc.).
- **Archived-At:** A direct link to the archived form of an individual email message.

Note that the To: field is not necessarily related to the addresses to which the message is delivered. The actual delivery list is supplied separately to the transport protocol, SMTP, which may or may not originally have been extracted from the header content. The "To:" field is similar to the addressing at the top of a conventional letter which is delivered according to the address on the outer envelope.

In the same way, the "From:" field does not have to be the real sender of the email message. Some mail servers apply email authentication systems to messages being relayed. Data pertaining to the server's activity is also part of the header, as defined below.

SMTP defines the trace information of a message, which is also saved in the header using the following two fields:

- **Received:** when an SMTP server accepts a message it inserts this trace record at the top of the header (last to first).
- **Return-Path**: when the delivery SMTP server makes the final delivery of a message, it inserts this field at the top of the header.

Other fields that are added on top of the header by the receiving server may be called trace fields, in a broader sense.

- **Authentication-Results**: when a server carries out authentication checks, it can save the results in this field for consumption by downstream agents.
- **Received-SPF**: stores results of SPF checks in more detail than Authentication-Results.
- **DKIM-Signature**: stores results of DomainKeys Identified Mail (DKIM) decryption to verify the message was not changed after it was sent.
- **Auto-Submitted**: is used to mark automatically generated messages.
- **VBR-Info: claims** VBR whitelisting

Content encoding

Internet email was originally designed for 7-bit ASCII. Most email software is 8-bit clean but must assume it will communicate with 7-bit servers and mail readers. The MIME standard introduced character set specifiers and two content transfer encodings to enable transmission of non-ASCII data: quoted printable for mostly 7-bit content with a few characters outside that range and base 64 for arbitrary binary data.

The BITMIME and BINARY extensionswere introduced to allow transmission of mail without the need for these encodings, but many mail transport agents still do not support them fully. In some countries, several encoding schemes coexist; as the result, by default, the message in a non-Latin alphabet language appears in non-readable form (the only exception is a coincidence, when the sender and receiver use the same encoding scheme).

Therefore, for international character sets, Unicode is growing in popularity.

Plain text and HTML

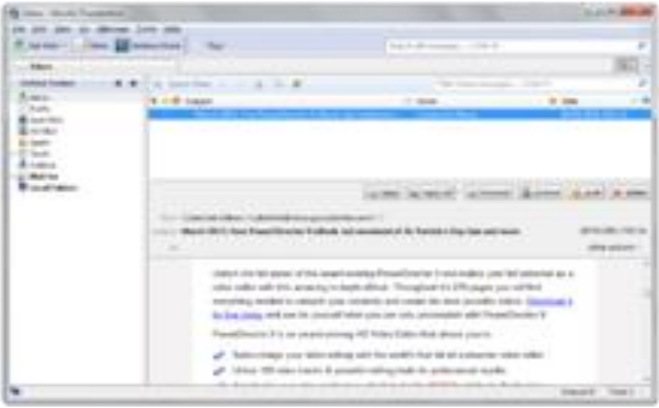
Most modern graphic email clients allow the use of either plain text or HTML for the message body at the option of the user.

HTML email messages often include an automatically generated plain text copy as well, for compatibility reasons. Advantages of HTML include the ability to include in-line links and images, set apart previous messages in block quotes, wrap naturally on any display, use emphasis such as underlines and italics, and change font styles.

Disadvantages include the increased size of the email, privacy concerns about web bugs, abuse of HTML email as a vector for phishing attacks and the spread of malicious software.

Some web-based mailing lists recommend that all posts be made in plain-text, with 72 or 80 characters per line for all the above reasons, but also because they have a significant number of readers using text-based email clients such as Mutt. Some Microsoft email clients allow rich formatting using their proprietary Rich Text Format (RTF), but this should be avoided unless the recipient is guaranteed to have a compatible email client.

Servers and client applications



The interface of an email client, Thunderbird.

Messages are exchanged between hosts using the Simple Mail Transfer Protocol with software programs called mail transfer agents (MTAs); and delivered to a mail store by programs called mail delivery agents (MDAs, also sometimes called local delivery agents, LDAs). Accepting a message obliges an MTA to deliver it, and when a message cannot be delivered, that MTA must send a bounce message back to the sender, indicating the problem.

Users can retrieve their messages from servers using standard protocols such as POP or IMAP, or, as is more likely in a large corporate environment, with a proprietary protocol specific to Novell Group wise, Lotus Notes or Microsoft

Exchange Servers. Programs used by users for retrieving, reading, and managing email are called mail user agents (MUAs).

Mail can be stored on the client, on the server side, or in both places. Standard formats for mailboxes include Maildir and mbox. Several prominent email clients use their own proprietary format and require conversion software to transfer email between them. Server-side storage is often in a proprietary format but since access is through a standard protocol such as IMAP, moving email from one server to another can be done with any MUA supporting the protocol.

Many current email users do not run MTA, MDA or MUA programs themselves, but use a web-based email platform, such as Gmail or Yahoo! Mail, that performs the same tasks. Such webmail interfaces allow users to access their mail with any standard web browser, from any computer, rather than relying on an email client.

Filename extensions

Upon reception of email messages, email client applications save messages in operating system files in the file system. Some clients save individual messages as separate files, while others use various database formats, often proprietary, for collective storage. A historical standard of storage is the mbox format. The specific format used is often indicated by special filename extensions:

eml

Used by many email clients including Novell GroupWise, Microsoft Outlook Express, Lotus notes, Windows Mail, Mozilla Thunderbird, and Postbox. The files contain the email contents as plain text in MIME format, containing the email header and body, including attachments in one or more of several formats.

emlx

Used by Apple Mail.

msg

Used by Microsoft Office Outlook and OfficeLogic Groupware.

mbx

Used by Opera Mail, KMail, and Apple Mail based on the mbox format.

Some applications (like Apple Mail) leave attachments encoded in messages for searching while also saving separate copies of the attachments. Others separate attachments from messages and save them in a specific directory.

URI scheme mailto

The URI scheme, as registered with the IANA, defines the `mailto:` scheme for SMTP email addresses.

Though its use is not strictly defined, URLs of this form are intended to be used to open the new message window of the user's mail client when the URL is activated, with the address as defined by the URL in the To: field.

Many clients also support query string parameters for the other email fields, such as its subject line or carbon copy recipients.

Web-based email

Many email providers have a web-based email client (e.g. AOL Mail, Gmail, Outlook.com, Hotmail and Yahoo! Mail). This allows users to log into the email account by using any compatible web browser to send and receive their email. Mail is typically not downloaded to the client, so can't be read without a current Internet connection.

POP3 email servers

The Post Office Protocol 3 (POP3) is a mail access protocol used by a client application to read messages from the mail server. Received messages are often deleted from the server. POP supports simple download-and-delete requirements for access to remote mailboxes (termed maildrop in the POP RFC's).

IMAP email servers

The Internet Message Access Protocol (IMAP) provides features to manage a mailbox from multiple devices. Small portable devices like smartphones are increasingly used to check email while traveling and to make brief replies, larger devices with better keyboard access being used to reply at greater length.

IMAP shows the headers of messages, the sender and the subject and the device needs to request to download specific messages. Usually, the mail is left in folders in the mail server.

MAPI email servers

Messaging Application Programming Interface (MAPI) is used by Microsoft Outlook to communicate to Microsoft Exchange Server - and to a range of other email server products such as Axigen Mail Server, Kerio

Connect, Scalix, Zimbra, HP OpenMail, IBM Lotus Notes, Zarafa, and Bynari where vendors have added MAPI support to allow their products to be accessed directly via Outlook.

Business and organizational use

Email has been widely accepted by businesses, governments and non-governmental organizations in the developed world, and it is one of the key parts of an 'e-revolution' in workplace communication (with the other key plank being widespread adoption of highspeed Internet). A sponsored 2010 study on workplace communication found 83% of U.S. knowledge workers felt email was critical to their success and productivity at work. It has some key benefits to business and other organizations, including:

Facilitating logistics

Much of the business world relies on communications between people who are not physically in the same building, area, or even country; setting up and attending an in-person meeting, telephone call, or conference call can be inconvenient, time-consuming, and costly. Email provides a method of exchanging information between two or more people with no set-up costs and that is generally far less expensive than a physical meeting or phone call.

Helping with synchronization

With real time communication by meetings or phone calls, participants must work on the same schedule, and each participant must spend the same amount of time in the meeting or call. Email allows asynchrony: each participant may control their schedule independently.

Reducing cost

Sending an email is much less expensive than sending postal mail, or long distance telephone calls, telex or telegrams.

Increasing speed

Much faster than most of the alternatives.

Creating a "written" record

Unlike a telephone or in-person conversation, email by its nature creates a detailed written record of the communication, the identity of the sender(s) and recipient(s) and the date and time the message was sent. In the event of a contract or legal dispute, saved emails can be used to prove that an individual was advised of certain issues, as each email has the date and time recorded on it.

Email marketing

Email marketing via "opt-in" is often successfully used to send special sales offerings and new product information.

Depending on the recipient's culture, email sent without permission—such as an "opt-in"—is likely to be viewed as unwelcome "email spam".

Personal computer

Many users access their personal emails from friends and family members using a personal computer in their house or apartment.

Mobile

Email has become used on smartphones and on all types of computers. Mobile "apps" for email increase accessibility to the medium for users who are out of their homes. While in the earliest years of email, users could only access email on desktop computers, in the 2010s, it is possible for users to check their email when they are away from home, whether they are across town or across the world.

Alerts can also be sent to the smartphone or other devices to notify them immediately of new messages. This has given email the ability to be used for more frequent communication between users and allowed them to check their email and write messages throughout the day. As of 2011, there were approximately 1.4 billion email users worldwide and 50 billion non-spam emails that were sent daily.

Individuals often check emails on smartphones for both personal and work-related messages. It was found that US adults check their email more than they browse the web or check their Facebook accounts, making email the most popular activity for users to do on their smartphones. 78% of the respondents in the study revealed that they check their email on their phone. It was also found that 30% of consumers use only their smartphone to check their email, and 91% were likely to check their email at least once per day on their smartphone. However, the percentage of consumers using email on a smartphone ranges and differs dramatically across different countries.

Declining use among young people

As of 2010, the number of Americans visiting email web sites had fallen 6 percent after peaking in November 2009. For persons 12 to 17, the number was down 18 percent. Young people preferred instant messaging, texting and social media. Technology writer Matt Richtel said in The New York

Times that email was like the VCR, vinyl records and film cameras—no longer cool and something older people do.

2015 survey of Android users showed that persons 13 to 24 used messaging apps 3.5 times as much as those over 45, and were far less likely to use email.

Attachment size limitation

Email messages may have one or more attachments, which are additional files that are appended to the email. Typical attachments include Microsoft Word documents, PDF documents and scanned images of paper documents. In principle there is no technical restriction on the size or number of attachments, but in practice email clients, servers and Internet service providers implement various limitations on the size of files, or complete email - typically to 25MB or less. Furthermore, due to technical reasons, attachment sizes as seen by these transport systems can differ to what the user sees, which can be confusing to senders when trying to assess whether they can safely send a file by email.

Where larger files need to be shared, various file hosting services are available and commonly used.

Information overload

The ubiquity of email for knowledge workers and "white collar" employees has led to concerns that recipients face an "information overload" in dealing with increasing volumes of email. With the growth in mobile devices, by default employees may also receive work-related emails outside of their working day. This can lead to increased stress, decreased satisfaction with work, and some observers even argue it could have a significant negative economic effect, as efforts to read the many emails could reduce productivity.

Spam

Email "spam" is unsolicited bulk email. The low cost of sending such email meant that, by 2003, up to 30% of total email traffic was spam, and was threatening the usefulness of email as a practical tool. The US CAN-SPAM Act of 2003 and similar laws elsewhere had some impact, and a number of effective anti-spam techniques now largely mitigate the impact of spam by filtering or rejecting it for most users, but the volume sent is still very high—and increasingly consists not of advertisements for products, but malicious content or links. In September 2017, for example, the proportion of spam to legitimate email rose to 59.56%.

Malware

A range of malicious email types exist. These range from various types of email scams, including "social engineering" scams such as advance-fee scam "Nigerian letters", to phishing, email bombardment and email worms.

Email spoofing

Email spoofing occurs when the email message header is designed to make the message appear to come from a known or trusted source. Email spam and phishing methods typically use spoofing to mislead the recipient about the true message origin. Email spoofing may be done as a prank, or as part of a criminal effort to defraud an individual or organization.

An example of a potentially fraudulent email spoofing is if an individual creates an email that appears to be an invoice from a major company, and then sends it to one or more recipients. In some cases, these fraudulent emails incorporate the logo of the purported organization and even the email address may appear legitimate.

Email bombing

Email bombing is the intentional sending of large volumes of messages to a target address. The overloading of the target email address can render it unusable and can even cause the mail server to crash.

Privacy concerns

Today it can be important to distinguish between the Internet and internal email systems. Internet email may travel and be stored on networks and computers without the sender's or the recipient's control.

During the transit time it is possible that third parties read or even modify the content. Internal mail systems, in which the information never leaves the organizational network, maybe more secure, although information technology personnel and others whose function may involve monitoring or managing may be accessing the email of other employees.

E-mail privacy, without some security precautions, can be compromised because:

E-mail messages are generally not encrypted.

E-mail messages have to go through intermediate computers before reaching their destination, meaning it is relatively easy for others to intercept and read messages. Many Internet Service Providers (ISP) store copies of email messages on their mail servers before they are delivered. The backups of these can remain for up to several months on their server, despite deletion from the mailbox.

Web bugs invisibly embedded in email content can alert the sender of any email whenever an email is read, or re-read, and from which IP address. It can also reveal whether an email was read on a smartphone or a PC, or Apple Mac device via the user agent string.

There are cryptography applications that can serve as a remedy to one or more of the above. For example, Virtual Private Networks or the Tor anonymity network can be used to encrypt traffic from the user machine to a safer network while GPG, PGP, SMEmail, or S/MIME can be used for end-to-end message encryption, and SMTP STARTTLS or SMTP over Transport Layer Security/Secure Sockets Layer can be used to encrypt communications for a single mail hop between the SMTP client and the SMTP server.

Additionally, many mail user agents do not protect logins and passwords, making them easy to intercept by an attacker. Encrypted authentication schemes such as SASL prevent this. Finally, the attached files share many of the same hazards as those found in peer-to-peer filesharing. Attached files may contain trojans or viruses.

Legal contracts

Emails can now often be considered as binding contracts as well, so users must be careful about what they send through email correspondence.

Flaming

Flaming occurs when a person sends a message (or many messages) with angry or antagonistic content. The term is derived from the use of the word incendiary to describe particularly heated email discussions. The ease and impersonality of email communications mean that the social norms that encourage civility in person or via telephone do not exist and civility may be forgotten.

Email bankruptcy

Also known as "email fatigue", email bankruptcy is when a user ignores a large number of email messages after falling behind in reading and answering them. The reason for falling behind is often due to information overload and a general sense there is so much information that it is not possible to read it all. As a solution, people occasionally send a "boilerplate" message explaining that their email inbox is full, and that they are in the process of clearing out all the messages.

Harvard University law professor Lawrence Lessig is credited with coining this term, but he may only have popularized it.

Internationalization

Originally Internet email was completely ASCII text-based. MIME now allows body content text and some header content text in international character sets, but other headers and email addresses using UTF-8, while standardized have yet to be widely adopted.

Tracking of sent mail

The original SMTP mail service provides limited mechanisms for tracking a transmitted message, and none for verifying that it has been delivered or read. It requires that each mail server must either deliver it onward or return a failure notice (bounce message), but both software bugs and system failures can cause messages to be lost.

To remedy this, the IETF introduced Delivery Status Notifications (delivery receipts) and Message Disposition Notifications (return receipts); however, these are not universally deployed in production. (A complete Message Tracking mechanism was also defined, but it never gained traction; see RFCs 3885 through 3888.) Many ISPs now deliberately disable non-delivery reports (NDRs) and delivery receipts due to the activities of spammers:

Delivery Reports can be used to verify whether an address exists and if so, this indicates to a spammer that it is available to be spammed.

If the spammer uses a forged sender email address (email spoofing), then the innocent email address that was used can be flooded with NDRs from the many invalid email addresses the spammer may have attempted to mail. These NDRs then constitute spam from the ISP to the innocent user.

In the absence of standard methods, a range of system based around the use of web bugs have been developed. However, these are often seen as underhand or raising privacy concerns, and only work with email clients that support rendering of HTML. Many mail clients now default to not showing "web content". Webmail providers can also disrupt web bugs by pre-caching images.

TRAİNİNG METHODS İMPLEMENTED İN COMPUTER TRAİNİNG PROGRAMS.

Many methods of training are available- each has certain advantages and disadvantages. Here we list the different methods of training...you can comment on the pros and cons and make the examples concrete by imagining how they could be applied in training truck drivers.

1. Technology-Based Learning

Common methods of learning via technology include:

- Basic PC-based programs
- Interactive multimedia - using a PC-based CD-ROM
- Interactive video - using a computer in conjunction with a VCR
- Web-based training programs

The forms of training with technology are almost unlimited. A trainer also gets more of the learner''s involvement than in any other environment and trainees have the benefit of learning at their own pace.

Example: In the trucking industry one can imagine interactive multimedia training on tractor-trailers followed by a proficiency test to see how well the employee knows the truck.

2. Simulators

Simulators are used to imitate real work experiences.

Most simulators are very expensive but for certain jobs, like learning to fly a 747, they are indispensable. Astronauts also train extensively using simulators to imitate the challenges and micro-gravity experienced on a space mission. The military also uses video games (similar to the "shoot-em-up" ones your 14-year old plays) to train soldiers.

Example: Truck drivers could use simulators to practice responding to dangerous driving situations.

3. On-The-Job Training

Jumping right into work from day one can sometimes be the most effective type of training.

Here are a few examples of on-the-job training:

- Read the manual - a rather boring, but thorough way of gaining knowledge of about a task.
- A combination of observation, explanation and practice.
- Trainers go through the job description to explain duties and answer questions.
- Use the intranet so trainees can post questions concerning their jobs and experts within the company can answer them.

On-the-job training gives employees motivation to start the job. Some reports indicate that people learn more efficiently if they learn hands-on, rather than listening to an instructor. However, this method might not be for everyone, as it could be very stressful.

Example: New trucking employees could ride with experienced drivers. They could ask questions about truck weigh stations, proper highway speeds, picking up hitchhikers, or any other issues that may arise.

4. Coaching/Mentoring

Coaching/mentoring gives employees a chance to receive training one-on-one from an experienced professional. This usually takes place after another more formal process has taken place to expand on what trainees have already learned.

Here are three examples of coaching/mentoring:

- Hire professional coaches for managers (see our HR.com article on Understanding Executive Coaching)
- Set up a formal mentoring program between senior and junior managers
- Implement less formal coaching/mentoring to encourage the more experienced employees to coach the less experienced.

Coaching/mentoring gives trainees the chance to ask questions and receive thorough and honest answers - something they might not receive in a classroom with a group of people.

Example: Again, truck drivers could gain valuable knowledge from more experienced drivers using this method.

5. Lectures

Lectures usually take place in a classroom-format.

It seems the only advantage to a lecture is the ability to get a huge amount of information to a lot of people in a short amount of time. It has been said to be the least effective of all training methods. In many cases, lectures contain no form of interaction from the trainer to the trainee and can be quite boring. Studies show that people only retain 20 percent of what they are taught in a lecture.

Example: Truck drivers could receive lectures on issues such as company policies and safety.

6. Group Discussions & Tutorials

These most likely take place in a classroom where a group of people discuss issues.

For example, if an unfamiliar program is to be implemented, a group discussion on the new program would allow employees to ask questions and provide ideas on how the program would work best.

A better form of training than lectures, it allows all trainees to discuss issues concerning the new program. It also enables every attendee to voice different ideas and bounce them off one another.

Example: Truck drivers could have group discussions and tutorials on safety issues they face on the road. This is a good way to gain feedback and suggestions from other drivers.

7. Role Playing

Role playing allows employees to act out issues that could occur in the workplace. Key skills often touched upon are negotiating and teamwork.

A role play could take place between two people simulating an issue that could arise in the workplace. This could occur with a group of people split into pairs, or whereby two people role play in front of the classroom.

Role playing can be effective in connecting theory and practice, but may not be popular with people who don´t feel comfortable performing in front of a group of people.

Example: Truck drivers could role play an issue such as a large line-up of trucks is found at the weighing station and one driver tells another that he might as well go ahead and skip the whole thing. Or role play a driver who gets pulled over by a police officer and doesn´t agree with the speeding charge.

8. Management Games

Management games simulate real-life issues faced in the workplace. They attract all types of trainees including active, practical and reflective employees.

Some examples of management games could include:

- Computer simulations of business situations that managers ′play′.
- Board games that simulate a business situation.
- Games surrounding thought and creativity - to help managers find creative ways to solve problems in the workplace, or to implement innovative ideas.

Example: In a trucking business, managers could create games that teach truckers the impact of late deliveries, poor customer service or unsafe driving.

9. Outdoor Training

A nice break from regular classroom or computer-based training, the usual purpose of outdoor training is to develop teamwork skills.

Some examples include:

- Wilderness or adventure training - participants live outdoors and engage in activities like whitewater rafting, sailing, and mountain climbing.

- Low-impact programming - equipment can include simple props or a permanently installed "low ropes" course.
- High-impact programming - Could include navigating a 40-foot "high ropes" course, rock climbing, or rappelling.

Outgoing and active participants may get the most out of this form of training. One risk trainers might encounter is distraction, or people who don´t like outdoor activities.

Example: As truck drivers are often on the road alone, they could participate in a nature-training course along with depot personnel to build esprit de corps.

10. Films & Videos

Films and videos can be used on their own or in conjunction with other training methods.

To be truly effective, training films and videos should be geared towards a specific objective. Only if they are produced effectively, will they keep the trainees attention. They are also effective in stimulating discussion on specific issues after the film or video is finished.

Films and videos are good training tools, but have some of the same disadvantages as a lecture - i.e., no interaction from the trainees.

A few risks to think about - showing a film or video from an outside source may not touch on issues directly affecting a specific company. Trainees may find the information very interesting but irrelevant to their position in the company.

Some trainers like to show videos as a break from another training method, i.e. as a break from a lecture instead of a coffee break.

This is not a good idea for two reasons. One: after a long lecture, trainees will usually want a break from any training material, so a training film wouldn´t be too popular. Two: using films and videos solely for the purpose of a break could get expensive.

Example: Videos for truckers could show the proper way to interact with customers or illustrate preventive maintenance techniques.

11. Case Studies

Case studies provide trainees with a chance to analyze and discuss real workplace issues. They develop analytical and problem-solving skills, and provide practical illustrations of principle or theory. They can also build a strong sense of teamwork as teams struggle together to make sense of a case.

All types of issues could be covered - i.e. how to handle a new product launch.

Example: Truck drivers could use case studies to learn what issues have been faced in the trucking industry in the past and what they could do if a similar situation were to occur.

12. Planned Reading

Basically planned reading is pre-stage preparation to more formal methods of training. Some trainees need to grasp specific issues before heading into the classroom or the team-building session.

Planned reading will provide employees with a better idea of what the issues are, giving them a chance to think of any questions beforehand.

Example: Here we may be stretching if we think that truckers are going to read through a lot of material the training department sends them.

Conclusion

Many avenues exist to train employees. The key is to match the training method to the situation. Assess each training method implemented in the organization and get feedback from trainees to see if they learned anything. Then take the results from the most popular and most effective methods to design a specific training program.

WHAT IS DISTANCE EDUCATION?

Distance education is defined as the practice of using correspondence, either written or virtual, to learn. With this practice, a teacher in New York could provide instruction to students all over the United States and the world. This helps students access teachers who may live geographically too far away to attend a class; it also assists students who cannot take classes during traditional hours because of work or other responsibilities.

While the exact start time of distance education is under debate, the earliest modern form can be traced back to Europe in the early 1800s. The earliest courses were pre-designed materials that would be mailed through the postal service to learners who could not attend universities either because of geography or the high cost of tuition and board. These early courses were called correspondence courses.

In these early courses, there were no opportunities for direct interaction, such as face-to-face meetings or instruction. The student would send an order form in the mail and receive a set of printed course materials. The student would review materials and return assignments in the mail, which the teacher would grade. At the end of the course, the student would take an examination and return the results via post. This provided no opportunities for students to ask questions about assignments or have a discussion with their teacher as it would have taken days or weeks to correspond.

By the late 1800s, correspondence courses had taken off, especially in the United States. Colleges and universities began offering correspondence courses, including some large schools such as Baylor University and the University of Chicago. As popularity in distance education grew, so did the number of schools offering the courses. By the mid-1900s, schools all around the world relied heavily on correspondence courses to supplement their on-campus student bodies.

Distance learning, also called **distance education, e-learning**, and **online learning**, form of education in which the main elements include physical separation of teachers and students during instruction and the use of various technologies to facilitate student-teacher and student-student communication. Distance learning traditionally has focused on nontraditional students, such as full-time workers, military personnel, and nonresidents or individuals in remote regions who are unable to attend classroom lectures. However, distance learning has become an established part of the educational world, with trends pointing to ongoing growth. In U.S. higher education alone, more than 5.6 million university students were enrolled in at least one online course in the autumn of 2009, up from 1.6 million in 2002.

An increasing number of universities provide distance learning opportunities. A pioneer in the field is the University of Phoenix, which was founded in Arizona in 1976 and by the first decade of the 21st century had become the largest private school in the world, with more than 400,000 enrolled students. It was one of the earliest adopters of distance learning technology, although many of its students spend some time in classrooms on one of its dozens of campuses in the United States, Canada, and Puerto Rico. A precise figure for the international enrollment in distance learning is unavailable, but the enrollment at two of the largest public universities that heavily utilize distance learning methods gives some indication: in the early 21st century the Indira Gandhi National Open University, headquartered in New Delhi, had an enrollment in excess of 1.5 million students, and the China Central Radio and

TV University, headquartered in Beijing, had more than 500,000 students.

Students and institutions embrace distance learning with good reason. Universities benefit by adding students without having to construct classrooms and housing, and students reap the advantages of being able to work where and when they choose. Public-school systems offer specialty courses such as small-enrollment languages and Advanced Placement classes without having to set up multiple classrooms. In addition, homeschooled students gain access to centralized instruction.

Characteristics Of Distance Learning

Various terms have been used to describe the phenomenon of distance learning. Strictly speaking, distance learning (the student's activity) and distance teaching (the teacher's activity) together make up distance education. Common variations include e-learning or online learning, used when the Internet is the medium; virtual learning, which usually refers to courses taken outside a classroom by primary- or secondary-school pupils (and also typically using the Internet); correspondence education, the long-standing method in which individual instruction is conducted by mail; and open learning, the system common in Europe for learning through the "open" university (see below).

Four characteristics distinguish distance learning.

First, distance learning is by definition carried out through institutions; it is not self-study or a nonacademic learning environment. The institutions may or may not offer traditional classroom-based instruction as well, but they are eligible for accreditation by the same agencies as those employing traditional methods.

Second, geographic separation is inherent in distance learning, and time may also separate students and teachers. Accessibility and convenience are important advantages of this mode of education. Well-designed programs can also bridge intellectual, cultural, and social differences between students.

Third, interactive telecommunications connect individuals within a learning group and with the teacher. Most often, electronic communications, such as e-mail, are used, but traditional forms of communication, such as the postal system, may also play a role. Whatever the medium, interaction is essential to distance education, as it is to any education. The connections of learners, teachers, and instructional resources become less dependent on physical proximity as communications systems become more sophisticated and widely available; consequently, the Internet, mobile phones, and e-mail have contributed to the rapid growth in distance learning.

Finally, distance education, like any education, establishes a learning group, sometimes called a learning community, which is composed of students, a teacher, and instructional resources—i.e., the books, audio, video, and graphic displays that allow the student to access the content of instruction. Social networking on the Internet promotes the idea of community building.

On sites such as Facebook and YouTube, users construct profiles, identify members ("friends") with whom they share a connection, and build new communities of like-minded persons. In the distance learning setting, such networking can enable students' connections with each other and thereby reduce their sense of isolation.

Correspondence schools in the 19th century

Geographical isolation from schools and dispersed religious congregations spurred the development of religious correspondence education in the United States in the 19th century.

For example, the Chautauqua Lake Sunday School Assembly in western New York state began in 1874 as a program for training Sunday school teachers and church workers. From its religious origins, the program gradually expanded to include a nondenominational course of directed home reading and correspondence study. Its success led to the founding of many similar schools throughout the United States in the Chautauqua movement.

It was the demand by industry, government, and the military for vocational training, however, that pushed distance learning to new levels. In Europe, mail-order courses had been established by the middle of the 19th century, when the Society of Modern Languages in Berlin offered correspondence courses in French, German, and English. In the United States, companies such as Strayer's Business College of Baltimore City (now Strayer University), which was founded in Maryland in 1892 and included mail-order correspondence courses, were opened to serve the needs of business employers, especially in the training of women for secretarial duties.

Most nonreligious mail-order correspondence courses emphasized instruction in spelling, grammar, business letter composition, and bookkeeping, but others taught everything from developing esoteric mental powers to operating a beauty salon. The clear leader in correspondence course instruction in American higher education at the end of the 19th century was the University of Chicago, where William Rainey Harper employed methods that he had used as director of the Chautauqua educational system for several years starting in 1883.

Early educational theories and technologies

Behaviourism and constructivism

During the first half of the 20th century, the use of educational technology in the United States was heavily influenced by two developing schools of educational philosophy. Behaviourism, led by the American psychologist John B. Watson and later by B.F. Skinner, discounted all subjective mental phenomena (e.g., emotions and mental images) in favour of objective and measurable behaviour. The constructive approach arose from ideas on progressive educationadvanced by the American philosopher John Dewey and others, who emphasized the education of the "whole child" to achieve intellectual, physical, and emotional growth and argued that learning is best accomplished by having children perform tasks rather than memorize facts. Constructivism, whose leading figure was the French developmental psychologist Jean Piaget, asserted that learning arises from building mental models based on experience.

These theories led to different techniques for the use of media in the classroom, with behaviourism concentrating on altering student behaviour and constructivism focusing on process- and experience-based learning.

Technological aides to education

One of the first technological aides to education was the lantern slide (e.g., the Linnebach lantern), which was used in the 19th century in chautauqua classes and lyceum schools for adults and in traveling public-lecture tent shows throughout the world to project images on any convenient surface; such visual aides proved particularly useful in educating semiliterate audiences. By the start of the 20th century, learning theories had begun concentrating on visual approaches to instruction, in contrast to the oral recitation practices that still dominated traditional classrooms.

The first significant technological innovation was made by the American inventor Thomas Edison, who devised the tinfoil phonograph in 1877. This device made possible the first language laboratories (facilities equipped with audio or audiovisual devices for use in language learning). After World War I, university-owned radio stations became commonplace in the United States, with more than 200 such stations broadcasting recorded educational programs by 1936.

Edison was also one of the first to produce films for the classroom. Many colleges and universities experimented with educational film production before World War I, and training films were used extensively during the war to educate a diverse and often illiterate population of soldiers in a range of topics from fighting technique to personal hygiene. Improvements in filmmaking, in particular the ability to produce “talkies,” were put to use just before and during World War II for technical training and propaganda purposes.

While the most artistically acclaimed propaganda production may have been Triumph of the Will (1935), one of a series of films made by Leni Riefenstahl during the 1930s for the German Nazi government, similar films were produced by all the major belligerents. In the

United States the army commissioned Hollywood film director Frank Capra to produce seven films, the widely acclaimed series Why We Fight (1942–45), in order to educate American soldiers on what was at stake.

Instructional television courses began to be developed in the 1950s, first at the University of Iowa. By the 1970s community colleges all across the United States had created courses for broadcast on local television stations. Various experiments in computer-based education also began in the 1950s, such as programmed or computer-assisted instruction, in which computers are used to present learning materials consisting of text, audio, and video and to evaluate students' progress.

Much of the early research was conducted at IBM, where the latest theories in cognitive science were incorporated in the application of educational technology. The next major advancement in educational technology came with the linking of computers through the Internet, which enabled the development of modern distance learning.

By the beginning of the 21st century, more than half of all two-year and four-year degree-granting institutions of higher education in the United States offered distance education courses, primarily through the Internet. With more than 100,000 different online courses to choose from, about one-quarter of American students took at least one such course each term. Common target populations for distance learning include professionals seeking recertification, workers updating employment skills, individuals with disabilities, and active military personnel.

Although the theoretical trend beginning in the 1990s seemed to be toward a stronger reliance on video, audio, and other multimedia, in practice most successful programs have predominately utilized electronic texts and simple text-based communications. The reasons for this are partly practical—individual instructors often bear the burden of producing their own multimedia—but also reflect an evolving understanding of the central benefits of distance learning.

It is now seen as a way of facilitating communication between teachers and students, as well as between students, by removing the time constraints associated with sharing information in traditional classrooms or during instructors' office hours. Similarly, self-paced software educational systems, though still used for certain narrow types of training, have limited flexibility in responding and adapting to individual students, who typically demand some interaction with other humans in formal educational settings.

Modern distance learning courses employ Web-based course-management systems that incorporate digital reading materials, podcasts (recorded sessions for electronic listening or viewing at the student's leisure), e-mail, threaded (linked) discussion forums, chat rooms, and test-taking functionality in virtual (computer-simulated) classrooms. Both proprietary and open-source systems are common. Although most systems are generally asynchronous, allowing students access to most features whenever they wish, synchronous technologies, involving live video, audio, and shared access to electronic documents at scheduled times, are also used.

Shared social spaces in the form of blogs, wikis (Web sites that can be modified by all classroom participants), and collaboratively edited documents are also used in educational settings but to a lesser degree than similar spaces available on the Internet for socializing.

Web-based services

Alongside the growth in modern institutional distance learning has come Web-based or facilitated personal educational services, including e-tutoring, e-mentoring, and research assistance. In addition, there are many educational assistance companies that help parents choose and contact local tutors for their children while the companies handle the contracts.

The use of distance learning programs and tutoring services has increased particularly among parents who homeschool their children. Many universities have some online tutoring services for remedial help with reading, writing, and basic mathematics, and some even have online mentoring programs to help doctoral candidates through the dissertation process.

Finally, many Web-based personal-assistant companies offer a range of services for adults seeking continuing education or professional development.

Open Universities

One of the most prominent types of educational institutions that makes use of distance learning is the open university, which is open in the sense that it admits nearly any adult. Since the mid-20th century the open university movement has gained momentum around the world, reflecting a desire for greater access to higher education by various constituencies, including nontraditional students, such as the disabled, military personnel, and prison inmates.

The origin of the movement can be traced to the University of London, which began offering degrees to external students in 1836. This paved the way for the growth of private correspondence colleges that prepared students for the University of London's examinations and enabled them to study independently for a degree without formally enrolling in the university.

In 1946 the University of South Africa, headquartered in Pretoria, began offering correspondence courses, and in 1951 it was reconstituted to provide degree courses for external students only. A proposal in Britain for a "University of the Air" gained support in the early 1960s, which led to the founding of the Open University in 1971 in the so-called new town of Milton Keynes.

By the end of the 1970s the university had 25,000 students, and it has since grown to annual enrollments in the hundreds of thousands. Open universities have spread across the world and are characterized as "mega-universities" because their enrollments may exceed hundreds of thousands, or even millions, of students in countries such as India, China, and Israel.

As one of the most successful nontraditional institutions with a research component, the Open University is a major contributor to both the administrative and the pedagogical literature in the field of open universities. The university relies heavily on prepared materials and a tutor system.

The printed text was originally the principal teaching medium in most Open University courses, but this changed somewhat with the advent of the Internet and computers, which enabled written assignments and materials to be distributed via the Web. For each course, the student is assigned a local tutor, who normally makes contact by telephone, mail, or e-mail to help with queries related to the academic materials.

Students may also attend local face-to-face classes run by their tutor, and they may choose to form self-help groups with other students. Tutor-graded assignments and discussion sessions are the core aspects of this educational model. The tutors and interactions between individual students are meant to compensate for the lack of face-to-face lectures in the Open University. To emphasize the tutorial and individualized-learning aspects of its method, the Open University prefers to describe it as “supported open learning” rather than distance learning.

From the start, correspondence courses acquired a poor academic reputation, especially those provided by for-profit entities. As early as 1926, as a study commissioned by the Carnegie Corporation found, there was widespread fraud among correspondence schools in the United States, and there were no adequate standards to protect the public.

While the situation was later improved by the introduction of accrediting agencies that set standards for the delivery of distance learning programs, there has always been concern about the quality of the learning experience and the verification of student work. Additionally, the introduction of distance learning in traditional institutions raised fears that technology will someday completely eliminate real classrooms and human instructors.

Because many distance learning programs are offered by for-profit institutions, distance learning has become associated with the commercialization of higher education. Generally, critics of this trend point to the potential exploitation of students who do not qualify for admission to traditional colleges and universities, the temptation in for-profit schools to lower academic standards in order to increase revenue, and a corporate administrative approach that emphasizes “market models” in educational curricula, or the designing of courses and curricula to appeal to a larger demographic in order to generate more institutional revenue—all of which point to a lowering of academic standards.

Distance learning, whether at for-profit universities or at traditional ones, utilizes two basic economic models designed to reduce labour costs. The first model involves the substitution of labour with capital, whereas the second is based on the replacement of faculty with cheaper labour.

Proponents of the first model have argued that distance learning offers economies of scale by reducing personnel costs after an initial capital investment for such things as Web servers, electronic texts and multimedia supplements, and Internet programs for interacting with students.

However, many institutions that have implemented distance learning programs through traditional faculty and administrative structures have found that ongoing expenses associated with the programs may actually make them more expensive for the institution than traditional courses.

The second basic approach, a labour-for-labour model, is to divide the faculty role into the functions of preparation, presentation, and assessment and to assign some of the functions to less-expensive workers.

Open universities typically do this by forming committees to design courses and hiring part-time tutors to help struggling students and to grade papers, leaving the actual classroom instruction duties, if any, to the professors. These distance learning models suggest that the largest change in education will come in altered roles for faculty and vastly different student experiences.

The emergence of Massive Open Online Courses (MOOCs) in the first and second decades of the 21st century represented a major shift in direction for distance learning. MOOCs are characterized by extremely large enrollments—in the tens of thousands—the use of short videotaped lectures, and peer assessments.

The open-online-course format had been used early on by some universities, but it did not become widely popular until the emergence of MOOC providers such as Coursera, edX, Khan Academy, and Udacity. Although the initial purpose of MOOCs was to provide informal learning opportunities, there have been experiments in using this format for degree credit and certifications from universities.

BLOOM'S TAXONOMY

EDUCATION

Bloom's taxonomy, taxonomy of educational objectives, developed in the 1950s by the American educational psychologist Benjamin Bloom, which fostered a common vocabulary for thinking about learning goals. Bloom's taxonomy engendered a way to align educational goals, curricula, and assessments that are used in schools, and it structured the breadth and depth of the instructional activities and curriculum that teachers provide for students. Few educational theorists or researchers have had as profound an impact on American educational practice as Bloom.

Understanding Education And Its Objectives

Throughout the 20th century, educators explored a variety of different ways to make both explicit and implicit the educational objectives taught by teachers, particularly in early education. In the early 20th century, objectives were referred to as aims or purposes, and in the early 21st century, they evolved into standards. During much of the 20th century, educational reformers who wanted to more clearly describe what teachers should teach began to use the word objectives, which referred to the type of student learning outcomes to be evidenced in classrooms. Bloom's taxonomy was one of the most significant representations of those learning outcomes.

Bloom's work was not only in a cognitive taxonomy but also constituted a reform in how teachers thought about the questioning process within the classroom. Indeed, the taxonomy was originally structured as a way of helping faculty members think about the different types of test items that could be used to measure student academic growth. Bloom and a group of assessment experts he assembled began their work in 1949 and completed their efforts in 1956 when they published Taxonomy of Educational Objectives: The Classification of Educational Goals, Handbook 1: Cognitive Domain.

Bloom's Cognitive Domains

Bloom's cognitive taxonomy originally was represented by six different domain levels: (1) knowledge, (2) comprehension, (3) application, (4) analysis, (5) synthesis, and (6) evaluation. All of the Bloom domains focused on the knowledge and cognitive processes. The American educational psychologist David Krathwohl and some of his associates subsequently focused on the affective domain, which is concerned with student interests, attitudes, and feelings. Another American educational psychologist, Anita Harrow, developed the psychomotor domains, which deal with a wide variety of motor skills. Bloom's work was most noted for its focus on the cognitive. Bloom became closely associated with the cognitive dimension even though, in subsequent work, he often examined the wide variety of "entry" characteristics (cognitive and affective) that students evidenced when they began their schooling.

Each of Bloom's cognitive domains enabled educators to begin differentiating the type of content being taught as well as the complexity of the content. The domains are particularly useful for educators who are thinking about the questioning process within the classroom, with questions ranging in complexity from lower-order types of knowledge to higher-order questions that would require more complex and comprehensive thought. Bloom's taxonomy enabled teachers to think in a structured way about how they question students and deliver content. The taxonomy, in both its original and revised versions, helped teachers understand how to enhance and improve instructional delivery by aligning learning objectives with student assessments and by enhancing the learning goals for students in terms of cognitive complexity.

The following list presents the structure of the original framework, with examples of questions at each of the six domain levels:

1. **Knowledge Level**: At this level the teacher is attempting to determine whether the students can recognize and recall information. Example: What countries were involved in the War of 1812?
2. **Comprehension Level:** At this level the teacher wants the students to be able to arrange or, in some way, organize information. Example: In the book Teammates the authors describe Jackie Robinson's struggles as a baseball player and the way in which Pee Wee Reese publicly defended Robinson. Describe in your own words the struggles that Robinson had and what Reese did to help him succeed as a baseball player.

3. **Application Level**: At this level the teacher begins to use abstractions to describe particular ideas or situations. Example: What would be the probable influence of a change in temperature on a chemical such as hydrochloric acid?

4. **Analysis Level:** At this level the teacher begins to examine elements and the relationships between elements or the operating organizational principles undergirding an idea. Example: Describe the way in which slavery contributed to the American Civil War.

5. **Synthesis Level**: At this level the teacher is beginning to help students put conceptual elements or parts together in some new plan of operation or development of abstract relationships. Example: Formulate a hypothesis about the reasons for South Carolina's decision to secede from the Union.

6. **Evaluation Level:** At this level the teacher helps students understand the complexity of ideas so that they can recognize how concepts and facts are either logically consistent or illogically developed. Example: Was it an ethical decision to take to trial the Nazi war

criminals and to subsequently put so many of them to death?

Bloom focuses primarily on the cognitive dimension; most teachers rely heavily on the six levels of the cognitive domain to shape the way in which they deliver content in the classroom. Originally Bloom thought about the characteristics that students possess when they enter school, and he divided those characteristics into the affective and the cognitive. From Bloom's perspective the learning outcomes are a result of the type of learning environment a student is experiencing and the quality of the instruction the teacher is providing.

The affective elements included the students' readiness and motivation to learn; the cognitive characteristics included the prior understandings the students possessed before they entered the classroom. In essence, a student who had an extensive personal vocabulary and came from a reading-rich home environment would be more ready to learn than the student who had been deprived of such opportunities during his preschool years. In the early 21st century, some reformers described this as the "knowledge gap" and specifically highlighted the fact that students from low socioeconomic settings have less access to books and a lower exposure to a rich home vocabulary. In essence, some of Bloom's original ideas continued to be reinforced in the educational research literature.

A Revision Of Bloom's Taxonomy

Many researchers had begun to rethink the way in which educational objectives were presented by teachers, and they developed a revision of Bloom's taxonomy in 2001. The revised taxonomy was developed by using many of the same processes and approaches that Bloom had used a half century earlier. In the new taxonomy, two dimensions are presented: the knowledge dimension and the cognitive dimension. There are four levels on the knowledge dimension: factual, conceptual, procedural, and metacognitive.

There are six levels on the cognitive process dimension:

1. remembering,
2. understanding,
3. applying,
4. analyzing,
5. evaluating,
6. creating.

The new taxonomy enabled teachers to think more in depth about the content that they are teaching and the objectives they are focusing on within the classroom. It allowed teachers to categorize objectives in a more-multidimensional way and to do so in a manner that allows them to see the complex relationships between knowledge and cognitive processes.

The original Bloom's taxonomy allowed teachers to categorize content and questions at different levels. The new two-dimensional model enabled teachers to see the relationship between and among the objectives for the content being taught and to also examine how that material should be taught and how it might be assessed.

By examining both the knowledge level and the cognitive processes, teachers were better equipped to consider the complex nature of the learning process and also better equipped to assess what the students learn.

The new taxonomy did not easily spread among practitioners, in part because most classroom teachers remained unfamiliar with the new taxonomic approach and because many professional development experts (including those in teacher-education institutions) continued to rely on the original taxonomy.

The new model was in many ways just as significant as the original taxonomy. The original approach provided a structure for how people thought about facts, concepts, and generalizations and offered a common language for thinking about and communicating educational objectives. In essence, it helped teachers think more clearly about the structure and nature of knowledge. The new taxonomy helped teachers see how complex knowledge really is.

PROS AND CONS OF USING ICT IN EDUCATION

There are many reasons why you should use technology in the classroom. There are also disadvantages too.

My personal reason is that technology to use in the classroom should:

1. Support subject learning
2. Technology can be used as a tool for learning other than a media for fun and;
3. Enable you to develop student ICT capability and ICT literacy alongside subject learning.

Below I have outlined what I consider to be the advantages and disadvantages of technology in the classroom. In general, school technology should always be used by students as a tool for learning and a means to an end by teachers. It should never be used just because it is there.

Additionally, simple exposure to technology in the classroom and the haphazard teaching of ICT skills will not sufficiently develop a child's ICT capability either when it is integrated in the curriculum or as a subject itself.

Here are what I consider the pros and cons to technology in the classroom.

Advantages

E-learning or Online Learning

The presence of ICT in education allows for new ways of learning for students and teachers.

ICT brings inclusion

Students with special needs are no longer at a disadvantage as they have access to essential material and special ICT tools can be used by students to make use of ICT for their own educational needs.

ICT promotes higher-order thinking skills

One of the key skills for the 21st century which includes evaluating, planning, monitoring, and reflecting to name a few.

ICT enhances subject learning

It is well known these days that the use of ICT in education adds a lot of value to key learning areas like **literacy** and numeracy.

ICT use develops ICT literacy and ICT Capability

Both are 21st-century skills that are best developed whilst ICT remains transparent in the background of subject learning.

ICT use encourages collaboration

ICT naturally brings children together where they can talk and discuss what they are doing for their work and this in turn, opens up avenues for communication thus leading to language development.

ICT use motivates learning

Society's demands for new technology has not left out children and their needs.

Children are fascinated with technology and it encourages and motivates them to learn in the classroom.

ICT in education improves engagement and knowledge retention

When ICT is integrated into lessons, students become more engaged in their work. This is because technology provides different opportunities to make it more fun and enjoyable in terms of teaching the same things in different ways

ICT use allows for effective Differentiation Instruction with technology

We all learn differently at different rates and styles and technology provide opportunities for this to occur.

ICT integration is a key part of the national curriculum

The integration of digital technologies or ICT is a significant part of the Australian Curriculum for example, and this is a trend that many global governments are taking up as they begin to see the significance of ICT in education.

Disadvantages of the technology to use in the Classroom

In my opinion, there are much fewer disadvantages of technology in the classroom.

Technology use in the classroom can be a distraction

True! Students may appear usefully occupied with the task when in fact they are working very inefficiently and failing to exploit the potential of ICT. They may divert from the intended task without it being too obvious. However, this is the reason why you should monitor technology to use in the classroom in addition to observing their learning progression in ICT.

Technology can detract students from social interactions

Oh no! This is not true. Some believe it is, however, you need to remember that technology in the classroom has a way of bringing students together. It has a natural ability to promote collaboration amongst students and also, there are many ways for students to socially interact with technology in the classroom like blogs. Do I need to go….?

Technology can foster cheating

This is perhaps true. Although, there are many ways or tools should I say for teachers to prevent this. Tools such as Turnitin etc. If this is referring to the Internet….then you should also think it no different than a student passing on a book to another student and pointing out the same lines.

Not all students have equal access

Out of all the cons, this may be more valid and hold more weight. If there is one thing that a pandemic teaches governments is that technology at times like this, increase the digital divide.

As you can see, the advantages and disadvantages of using technology in the classroom are balanced in favour of the many opportunities that technology brings to teaching and learning. Despite this, for some change is not what is considered important to them as they cling to the teaching methods in primary school classroom practices that work the best for them.

For these people, the disadvantages of technology in the classroom have more weight and influence than the advantages of technology in the classroom and this is despite the continuing evidence that shows that if change does not occur in the classroom, those who favour the disadvantages the most will be left behind.

The pros and cons of technology in the classroom remain a deciding factor for many teachers in an online and digital world.