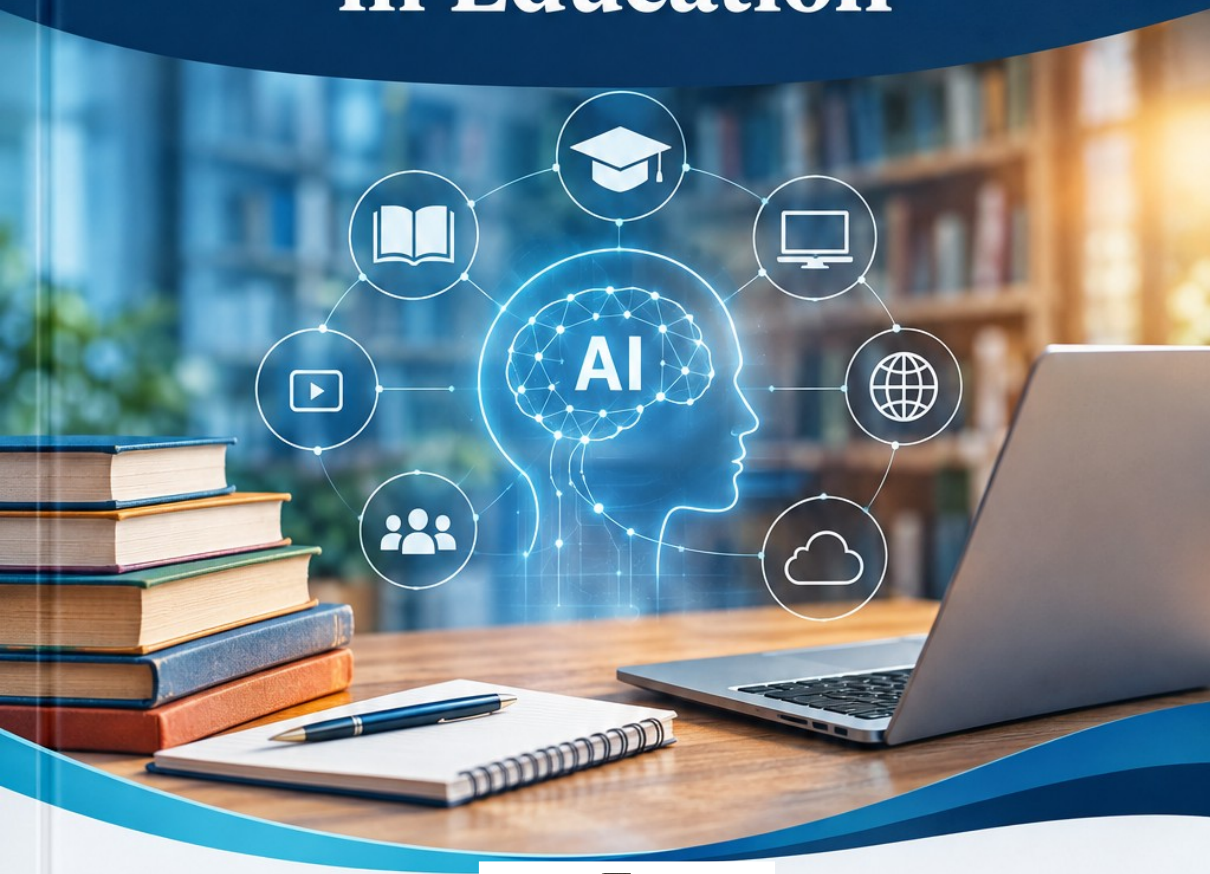
Tinatin Mshvidobadze

Modern Educational Technologies and Artificial Intelligence in Education



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Author

Tinatin Mshvidobadze

Farabi Yayınevi

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INTRODUCTION

Technology-based learning in the early 21st century is transforming the way people learn at a time when two powerful trends converge. The first trend is the rapid acceleration of technological change and the demand that this change places on education and workforce training during their professional live. The education, secondary and tertiary cycles uses more often the technology in the educational processes, on one side. This is very important because brings a new trend in the educational field and can be applied at all the levels. On the other side, while successful economies have always depended on a skilled and knowledgeable workforce, today's rate of change in production processes and workplace tools requires much more training and retraining of individuals on the job than it did in the past. As more workers become knowledge workers, the demand for frequent retraining and specialization is further accelerated with each technological shift. Industry has to be able to retrain its workforce much more quickly, and the development cycles of training programs have to be shortened if companies want to stay competitive. Given that updating workers' skills rapidly and as the need arises is so critical in today's economy, the efficiency with which companies do so can thus be critical in helping them maintain a competitive edge.

Educational technology, often abbreviated as EdTech, is a rapidly evolving field that is revolutionizing the way we teach and learn. In an era of constant technological advancement, it has become imperative for educational institutions to embrace innovative tools and strategies that enhance student engagement, promote personalized learning, and prepare learners for a future marked by digital literacy. This article explores the various aspects of educational technology, its benefits, challenges, and its potential to reshape the landscape of education.

The advent of technology has precipitated significant transformations in almost every aspect of human life, and education is no exception. Educational technology, or EdTech, represents a revolutionary approach to teaching and learning that seeks to integrate technology into educational processes to enhance educational outcomes and experiences. By leveraging digital tools, multimedia resources, and interactive platforms, EdTech aims to address the evolving needs and challenges of education in the 21st century. The roots of educational technology can be traced back to the early use of audiovisual aids, such as projectors and educational films, in classrooms.

However, it wasn't until the rapid advancement of computers and the internet in the late 20th century that EdTech began to truly flourish. The integration of computers into education brought about a paradigm shift, providing new possibilities for interactive learning and information access.

In recent years, the proliferation of smartphones, tablets, and other portable devices has further accelerated the adoption of educational technology. Digital textbooks, online courses, educational apps, and gamified learning platforms have become increasingly prevalent, blurring the lines between traditional and digital learning environments. This shift has not only affected the way students learn but also influenced the role of educators as facilitators and guides in the learning process.

Today, society has already changed its priorities, the term “information society” has appeared, which is interested in its citizens being able to make independent decisions and quickly adapt to changing conditions. All these circumstances require new research in the field of subject teaching methodology, the search for innovative strategies, forms and methods of upbringing and education, which are associated with the development and introduction of modern educational and information technologies in the educational process. The competence of teachers in the most effective use of information, interactive communication technologies in the establishment and development of the universal sphere of education is increasing, the formation of a new pedagogical thinking culture is being stimulated. The use of modern pedagogical technologies in the educational process of a higher educational institution creates completely new opportunities for the introduction of didactic principles of individualization and differentiation in teaching, has a positive effect on the cognitive development of students. On the development of activity, their creative activity, and awareness.

The textbook presents modern approaches to the development of various educational technologies. The conditions and factors under which the development and use of innovative technologies in education can be analyzed are discussed. The concept of a systematic methodology and the constructive principles of technological support of educational activities are substantiated.

1. THE ROLE OF EDUCATIONAL TECHNOLOGY IN MODERN EDUCATION

Personalized learning: Educational technology allows educators to tailor learning experiences to individual students' needs, preferences, and learning styles. With the aid of adaptive learning platforms, algorithms can analyse students' progress and adjust content and pacing to match their abilities, fostering more effective learning experiences

Accessibility and inclusivity: Technology has the potential to break down barriers and make education accessible to diverse learners, including those with disabilities. Assistive technologies and e-learning platforms with built-in accessibility features enable students with different learning needs to engage with educational content in a manner that suits them best.

Engagement and interactivity: Interactive learning tools like gamification, virtual reality, and educational apps captivate students' attention and promote active participation. Gamified learning, for instance, employs game elements to make the learning process enjoyable and motivating, leading to improved retention and comprehension.

Global connectivity: Educational technology facilitates global collaboration and cultural exchange among students and educators from different parts of the world. Online communication platforms and virtual classrooms create a borderless educational experience, fostering cross-cultural understanding and expanding students' horizons.

Improved learning outcomes: Research has shown that integrating technology into education can lead to improved student performance, higher test scores, and increased retention of information. Interactive multimedia and visual aids enhance comprehension and make complex subjects more accessible.

Enhancing teacher effectiveness: Educational technology empowers educators by providing them with data-driven insights into students' progress and learning patterns. This data-driven approach enables

teachers to make informed decisions, personalize instruction, and identify areas where students may need additional support.

Lifelong learning opportunities: EdTech extends learning beyond traditional classroom settings. Through online courses, webinars, and educational resources, learners of all ages can access knowledge at their convenience, promoting lifelong learning and professional development.

Cost-effectiveness: While the initial investment in educational technology may be significant, it often proves cost-effective in the long run. Digital textbooks, for example, eliminate the need for printed materials, reducing printing and distribution costs.

1.1. Challenges And Concerns

Despite the numerous advantages of educational technology, it is essential to acknowledge and address some of the challenges associated with its implementation:

Digital divide: The digital divide refers to the disparity in access to technology and the internet. Not all students have equal access to devices and high-speed internet connections, which can lead to inequalities in educational opportunities.

Privacy and security: As educational technology involves the collection and storage of student data, ensuring the privacy and security of this information is crucial. Institutions must adopt robust cybersecurity measures to protect sensitive data from potential breaches.

Teacher training and support: Integrating technology effectively in the classroom requires teachers to possess adequate digital literacy and receive continuous training and support. Without proper preparation, educators may struggle to leverage technology to its full potential.

Screen time and distractions: Over-reliance on technology can lead to increased screen time for students, potentiallys leading to distractions and health concerns. Striking a balance between digital and non-digital learning experiences is essential for students' well-being.

Future directions of educational technology: The future of educational technology looks promising, with ongoing developments and innovations that hold the potential to transform education further. Here are some of the key directions for EdTech- Artificial Intelligence (AI) in Education, AI-powered learning platforms can analyze vast amounts of data to provide personalized feedback, create customized learning paths, and even develop AI tutors capable of addressing individual students' needs.

Augmented and virtual reality: Augmented and virtual reality technologies have immense potential in providing immersive learning experiences, enabling students to explore historical sites, visit distant planets, or understand complex scientific concepts in an interactive and engaging manner.

Block chain for credentialing: Block chain technology can revolutionize the way academic credentials and certificates are stored and verified, enhancing their security, portability, and transparency.

Educational technology continues to reshape the landscape of education, offering endless possibilities for enhancing learning experiences, promoting student engagement, and preparing learners for a technology-driven world. By addressing challenges such as the digital divide, privacy concerns, and proper teacher training, educational institutions can harness the full potential of EdTech to create a more inclusive, personalized, and effective learning environment for all students. Embracing the dynamic and ever-evolving field of educational technology is key to unlocking a brighter and more innovative future for education.

Educational technology has profoundly impacted the education landscape, propelling it into an era of innovation and accessibility. As technology continues to evolve, the key lies in using it judiciously to enhance learning outcomes and empower learners and educators alike. By embracing EdTech thoughtfully and addressing its challenges, we can pave the way for a more inclusive, personalized, and globally connected future of education.

1.1. 1.2. Using Modern Technology For Improving Learning Process At Different Educational Levels

Technology based learning is transforming training and education by providing new technological opportunities to address new learning needs.

Technology-based learning programs come in different delivery modes and forms. They can include online tools, such as discussion boards and e-mail, and real time events, through videoconferencing and web conferencing. They can be self-paced, and have a varying focus of instruction. Technology-based learning uses a series of delivery methods and hardware and software tools to manage and deliver learning content and manage and track learner progress, as well as learner-to-learner and learner-toinstructor communication. The methods used for teaching and learning in the informational environment are: Tutorials are self-paced training programs delivered online or from a CD-ROM; Web Conferences are synchronous meetings in a virtual environment; Online Forums (also called bulletin boards, discussion groups, or news groups); Electronic Mailing Lists allow members to send messages to other members of the same mailing list; Virtual Collaborative Workspaces; Simulations; Goal-Based Scenarios; Learning Management Systems; Integrated Learning Systems; Synchronous and Asynchronous Delivery Modes Technology-based.

1.2.1. Sectors Of Application

1.Education

At different educational levels technology is used as a component of blended learning programs meant to improve traditional curriculum by providing authentic learning experiences. Instructors often implement blended learning to teach students to use technology as well as to help them apply the technology to develop math, science, and reading skills. Researchers have found that Technology based learning components promote active learning and ownership of the learning experience for students. This is part because the Internet provides students with the immediate opportunity to research topics they are studying in class and build on information they acquire from traditional classroom instruction.

2. Post-Secondary Education

Technology-based learning has provided traditional students with opportunities to access the best programs offered by a variety of educational institutions and offer working adults more access to education and professional specialization thorough distance learning. The use of technology based learning in post-secondary institutions is continuously growing. Other delivery systems include networks and affiliations of colleges that join together to offer learners the best of each institution's courses. Students work with their own college degree or certificate program and receive credit for courses they complete through other institutions belonging to the network or affiliation. Another growing trend in delivery systems is the public-private technology-based learning partnerships. Certainly, post-secondary institutions in the world have fostered significant innovation in technology-based learning strategies, with one of the most common being the online university.

3.Economy

Private corporations have made great efforts to capitalize on the benefits of technology-based learning. The web and computer-based models are especially valuable to companies in competitive markets and those with a large and widely dispersed employee base. More and more private companies realize the importance of investing in a quality workforce while maximizing profits through cost-effective technology-based learning programs. Although overall training budgets fell considerably in 2009 due to the global economic crisis, many companies are choosing to spend money on e-learning due to the efficiency of the solutions offered. Employees take advantage of these opportunities through integrated on-the-job training as well as off-site professional development programs.

4. Public sector

Government at state and local level has turned its attention to technology-based learning as a cost-effective strategy to provide training and professional development for the workforce; up-to-date, on-demand training for military personnel and other government workers. Current issues of importance to governments in every country include funding for accessibility, intellectual property, and the standardization of management systems throughout learning environments. Reports from these bodies point to technology based learning, is related to the capacity to produce a stronger, better qualified workforce if advances are made in these areas.

1.2.2. Benefits And Challenges

Technology based learning comes with substantial benefits for the human capital and society. Most of all, it offers geographic reach and a scalability of training and educational efforts that face-to-face interaction cannot achieve. It also offers a wide range of learning modes and an opportunity to track progress and measure outcomes as a seamless part of learning. However, as with all technology applications, the use of technology in itself poses some new challenges. In technology based learning process, the most significant problem is the digital divide, which still splits the countries into digital haves and digital have-nots. In addition, transferring learning into a technology based learning environment creates additional challenges for educators and training designers.

1.2.3. Benefits

There are numerous advantages to technology based learning in comparison to face-to-face learning. Five of the primary benefits are the following: Accessibility for all the persons who intend to follow any type of courses; Learning Matched to learners' need; Scalability: Well-designed technology based training programs can also accommodate larger volumes of customers at little extra cost. Timely Update; Streamlined and Effective Learning Delivery.

1.2.4. Challenges

The introduction of technology based learning at all the educational levels is not without challenges. They include: Digital Divide: The Digital Divide directly affects technology based learning implementation since a significant portion of the population still does not have access to computers or to the Internet. Internet use is lowest for low income people, those who are over 50 years old, the unemployed, and individuals who have never attended college. Social Loafing: technology based learning is also more likely to produce "social loafing," in which learners reduce their level of effort when they perceive that doing so will not have negative social effects. *Accommodation for Individuals with Disabilities:* Access to technology based learning courses for individuals with disabilities can also pose a challenge. While technology based learning generally offers access options for those disabilities, accommodations must be made in order for technology based learning to be accessible.

Compatibility: Another challenge for technology based learning is the need for compatible technology. Development Costs: Another disadvantage of technology-based learning is high upfront development costs, which can require significant programs, because they spent so many hours developing the materials and so few students enrolled in the course.

Lack of Credibility: Lastly, technology based learning degree programs still lack the level of credibility of traditional degree programs.

To be used effectively for the educational processes technology based learning, must exploit this delivery system's key advantages, adhering to some key principles. Human interaction is important. Interaction with instructors and peers can be important to learner satisfaction and can provide the reinforcement that learners need to gain competency. Provide opportunities for active engagement.

E-learning that consists of reading material on a computer display or drill-and-kill exercises does not exploit the potential of technology based learning and is unlikely to be very effective. Make the content relevant and timely. Building off a constructivist approach to learning, e-learning—as indeed traditional learning—must be perceived as relevant to learners and, to be mastered and retained, content must be connected to things they already know. Provide feedback and support. Technology based learning runs the risk of isolating learners as they proceed through their learning exercises

2. MODERN INFORMATION TECHNOLOGIES IN DISTANCE LEARNING

2.1. Distance Technologies As A Component Of The Process Of Forming Soft Skills

The modern state of the higher education system requires the search for new ways of organizing the educational process, which will ensure the formation of socially significant characteristics of the future teacher. Among such characteristics is a complex of non-specialized, non-professional skills, which are responsible for successful participants in the work process, high efficiency and are not related to a specific field.

According to studies conducted at Harvard and Stanford universities, only 15% of career success is provided by the level of professional skills. And 85% is provided by soft skills. In Ukraine, universities play an important role in the development of “soft skills”, taking into account the requirements of the labor market.

Considerable attention should be paid to the development of creativity, which, according to scientists, is associated with the mental activity of a person.

The creative individuality of a specialist is a systematic, integral personal phenomenon, which includes a set of intellectual, motivational, motivational-volitional and professional-value characteristics.

The educational process develops creativity taking into account the following principles:

- awareness (this is achieved during reflection on the process and result);
- management of subject activity (self-organization); self-expression - changes (for the purpose of improvement) with further development in the process of constant transition from one state to another.

Process of education will develop the creativity considering such principles:

- ✓ awareness (it is achieved during the reflection of the process and result);
- ✓ management of subject activity (self-organization); self-expression – changes (with the aim of improvement) along with the further development during the process of the constant move from one state to another: from less effective to the more effective.

We consider that due to the reflexive position of the student it is formed the experience of the creative activity through the actualization of the creativity itself and the student transforms from the passive receiver into the active subject of cognition.

The construction of the conceptual model of formation of the creative professional potential of the future specialists helps to understand better the process of formation of the creative potential and allows to construct the methodic of formation of creative professional potential of the future specialists with the help of distance technologies. Within modern conditions of the society's development the distance learning has become the global phenomena of the social culture, in particular, educational and informational culture. However the distance form of education has not been used yet for the development of the creativity of the applicants for higher education. Modern-days conditions which are connected with the implementation of the quarantine's means significantly complicate the organization of the effective teaching of the applicants for higher education. The implementation of the quarantine on the territory of Ukraine and some other measures of the prevention of the spreading of the coronavirus disease makes the scientific and pedagogical community to look for the appropriate opportunities which will help to provide the development of the creativity of the future specialists, creation of pedagogical conditions for the revealing of the students' potential. One of such measures which have unique opportunities, is the distance learning.

We can visually represent the hierarchy of the systems of distance learning as the pyramide which is given in the Fig. 1.

At the base of the pyramid there the means of course development. These systems provide the opportunity of developing distance educational materials on the basis of the visual programming or text editors.

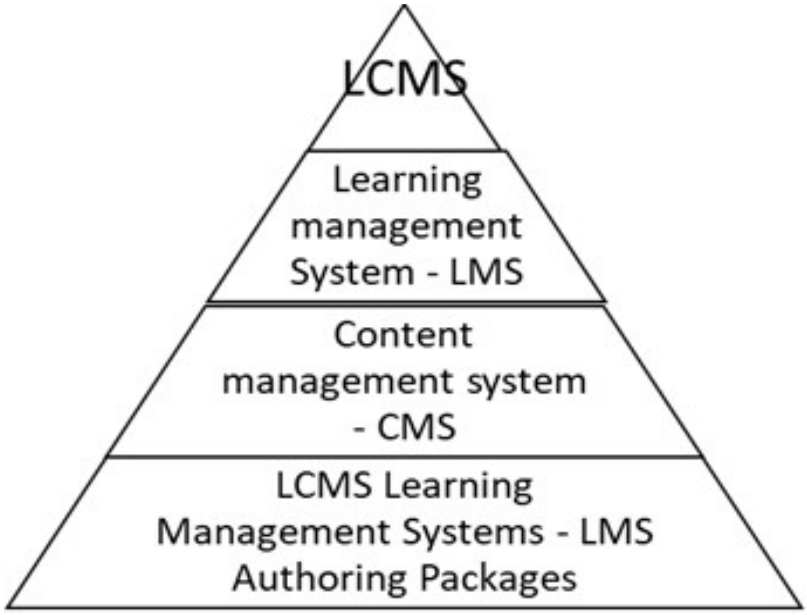


Fig. 1.1. Hierarchy of distance learning systems

For the formation of the creative pedagogical potential of the future specialists it is necessary to implement the systematic approach of the modernization of the informational-communicative environment, integration of the informational-communicative technologies and psychological pedagogical conditions within the educational process.

The integration of the psychological pedagogical conditions and informational-communicative environment allows to realize the programmed approach to the formation of the creative pedagogical potential of the future specialists9. Within the implementation of the programmed approach to the formation of the creative professional potential of the future specialists during the process of the professional training there were used way which are given in the Table 1.

Table 1

NAME	DESCRIPTION
MOODLE	Learning management system
GOOGLE CLASSROOM	Web-service for the organization of learning
WORDPRESS	System of content management
YOUTUBE	Video-hosting which gives services on distribution video-materials
BANDICAM	Program for the recording video from the screen
CAMTASIA STUDIO	Program for the recording video from the screen
GOOGLE MAPS	Map-graphic system (mapping system
GOOGLE TRANSLATE	Translation of words, texts, phrases, web-pages
GOOGLE DOCS	Text editor
GOOGLE SHEETS	Table editor
GOOGLE SLIDES	Presentation editor
GOOGLE FORMS	Survey administration
BLOGGER	Blogging-platform

Google Classroom a Moodle allow to create the personally-oriented, developing educational environment. We have created tasks for the individual and independent work. These tasks are oriented on development of the students' professionally important qualities on each topic of the discipline. For the realization of the phased character of the pedagogical forming impacts it is necessary to include testing into the independent work. This will permit to determine the student's stage of the formation of creative professional potential.

The input testing will also allow to conduct the research and monitoring of the effectiveness of the implementation of the pedagogical technologies.

2.2. Multimedia Educational Presentations As A Means Of Forming Professional Foreign Language Competence Of Future Philologists

Pedagogical technology is interpreted by researchers as a set of tools and methods of reproduction of theoretically substantiated processes of learning and upbringing, which allow implementing the educational goals successfully. In the light of the studying tasks, it is considered the pedagogical technology of introducing the multimedia educational presentation (MEP) as a set of forms, methods, and means of organizing the process of professional foreign language training by means of multimedia technologies, which aims to ensure the successful formation of all the components of the professional foreign language competence (PFLC) of future philologists.

In the context of the problem of organizing professional foreign language training of future philologists using the MEP, the leading place in this process belongs to the lecturer, who is its equal participant and who allows intensifying student activities and stimulating personal and professional development and self-development of future philologists which leads to the achievement of specific learning goals in the shortest possible time and with the least expenditure of pedagogical efforts and resources.

It should be noted that organizing the process of the PFLC formation using the MEP takes into account the principles of using multimedia teaching aids, the theoretical basis for which are the personality-directed and communicative-activity approaches. The principles presented are the components of the suggested technology that influence the process of selection of forms, methods, and means of teaching. The form of organizing the learning process is a didactic category, which means the external side of organizing the educational process. This is a specially organized activity of the lecturer and students, which proceeds according to the established procedure and regime. The form of organizing the learning process is a purposeful, clearly organized, meaningful, and methodically equipped system of cognitive and educational communication, interaction, relations between the lecturer and students. The result of such interaction is the professional development of the lecturer, personal and professional development of students, their acquisition of knowledge, formation, and development of relevant skills and abilities. It is known that there are five general organizational forms of work:

individual, in pairs, in groups, frontal, and collective. Their combination gives specific forms of educational work (practical classes, independent work, etc.).

In the suggested pedagogical technology, we use traditional for the higher school forms of organizing the learning process using the MEP: practical classes; individual independent.

On analyzing the studies of scientists concerning the problem of organizing the learning process18, it should be noted that in order to achieve optimal results it is necessary to combine forms and methods, giving priority to those that ensure the highest efficiency of the educational process. This opinion is relevant in our study because the peculiarity of epy educational-cognitive activities at higher school is to strengthen the role of students' individual educational work. That is why, the important problem of higher education is the formation of students' ability to navigate independently in the flow of scientific information, the ability to independently replenish their knowledge. Therefore, the acquisition of professional knowledge and skills occurs through organizing their own cognitive activity. Scientists note that learning can be interesting, exciting if it is brightly illuminated by active thought, deep feelings, the desire for creativity19. Taking into account the above mentioned, in the suggested pedagogical technology it should be given the priority to active forms and methods of teaching, which provide for such an organization of the learning process using the MEP, which is focused on the development of future philologists' cognitive activity, independence, competence, self-criticism.

The criteria for selecting methods (concerning the forms) are compliance with certain theoretical principles and principles governing the process of the professional foreign language training of future philologists using multimedia teaching aids. Teaching methods in the modern scientific literature are interpreted as ways of orderly, interconnected activities of lecturers and students, through which the acquisition of knowledge, skills, and abilities is achieved, students' worldview is formed, their qualities and abilities are developed

There are many different classifications of methods depending on the chosen criterion (the source of knowledge acquisition, degree, and nature of participation in the learning process, method of work). Taking into account the theoretical provisions on the organization of the process of forming the PFLC of future philologists using the MEP, it is more preferable the classification based on the activity approach to learning. According to this classification,

there are three groups of methods: 1) methods which provide mastery of the subject (verbal, visual, practical, etc.); 2) methods of stimulating and motivating the learning process (role-playing, business games, educational discussions, project-based learning); 3) methods of control and self-control of educational activities (surveys, testing, etc.). At the same time, researchers note that since both the lecturer and students are involved in the learning process, the methods should be considered in the form of two interrelated groups: 1) teaching methods used by the lecturer to present new material, organize its assimilation and control; 2) learning methods used by students in the process of their cognitive and practical activities. Taking into account the two-way interaction of participants (the lecturer and student) in the process of the professional foreign language training of future philologists, this classification is relevant in the plane of the problem studied.

The communicative-activity orientation of the process of the PFLC formation and the principle of the communicative orientation of the professional foreign language training of future philologists lead to the use of the following basic teaching methods: demonstration; explanation; organization of training and practice. Accordingly, students use the following learning methods: acquaintance; comprehension; participation in training, and practice.

The main methods of teaching and learning are not only a means but also a purpose in itself, not only a process but also a content, a source of personal experience, a factor of actualization of meaningful, reflective, critical, and other individual functions, which emphasizes their value from the standpoint within the problem under consideration.

The method of demonstration is used by the lecturer in order to present new educational material at different levels of its organization (sounds, words, sentences, microtexts, situations, instructions to the text, etc.). The result of the demonstration is the formation of students' ideas about the language unit. Therefore, students use the method of acquaintance. Demonstration and acquaintance involve presentations-demonstrations (visual, textual, combined), prepared by the lecturer. The method of explanation also requires the involvement of visual, textual, or combined presentations-topics, presentations-demonstrations.

The result of the appropriate method of comprehension of educational material by students is the knowledge that forms the basis for the performance of speech actions. The method of organizing the training activities involves students' activities in the form of training exercises in order to develop

language and speech skills. Language exercises provided by the content of the MEP, provide students with awareness of the meaning and form of language units, and speech exercises are aimed at using language units in communication within a particular topic that can be associated with the content of utterances. Thus, using the above methods provides acquiring the philological knowledge and forming the relevant skills of future philologists.

The principle of the communicative orientation of the professional foreign language training of future philologists involves using such verbal methods as a conversation and educational discussion. The task of the conversation is to encourage the actualization of the known and the acquisition of new knowledge through independent reflection, conclusions, and generalizations24. In pedagogical practice, the following methods of conversation are used: asking questions (basic, additional), discussing answers, correcting them, formulating conclusions. According to didactic purposes, they are divided into introductory, informative, repetitive-generalizing, and controlcorrective. Within the suggested pedagogical technology, it is used conversation as one of the Educational discussion is a verbal method of teaching, the essence of which is to exchange views on a particular problem in order to acquire new knowledge, strengthen one's own opinion, to form the ability to defend it. There are the following characteristics of educational discussion: 1) wide discussion (exchanging views); 2) presence of a controversial issue (problem); 3) publicity (presence of an audience); 4) verbal form of communication (dialogue or polylogue), although it is possible to use a variety of visuals during presenting the speech at the proof stage; 5) presence of at least two persons (or groups) with opposing views; 6) spontaneity26. The wide introduction of group discussion in the educational process gives a new impetus to the development of problem-based learning, independence of students in acquiring new knowledge, stimulates their cognitive interest. Taking into account the fact that the indicators of the formation of the PFLC of future philologists are the ability to perform foreign language communication depending on the situation, choose effective means of communication, have communication strategies, be tolerant of other communicators, dynamic and communicative, it is considered appropriate to use the method of educational discussion in the suggested technology.

The principle of modeling the professional activity of future philologists and the principle of the communicative direction of the professional foreign language training lead to the appeal to such methods of

stimulation and motivation as a role-playing and business game. By its definition, a game is a type of activity in situations aimed at reproducing and assimilating social experience, in which self-management of behavior is formed and improved. The purpose of using role-playing and business games is the forming and developing skills and abilities of professional foreign language communication under conditions as close as possible to the conditions of real communication or those that imitate it.

During role-playing, a high level of being involved in work, forming critical and reflective thinking in students, stimulating their activity and initiative, reliance on life experience as a source of knowledge. From the standpoint of the communicative-activity approach, role-playing appears as an educational task that covers language, communicative and activity components. Solving the communicative task involves forming language skills, improving speech skills through the purposeful use of the given language material in speech activity. In turn, the communicative task determines exchanging information between the participants of the game in the process of joint speech activities. Instead, the activity task models the way of such joint activities of communication partners.

Because of the above presented, it is considered the use of the role-playing method relevant within the outlined pedagogical technology, as its use contributes to the acquisition of personal and communicative experience and the development of professionally significant qualities and skills by future philologists. In the practice of the professional foreign language training of future philologists, role-playing games are well combined with business ones. The business game as one of the types of a role-playing game is a form of reproducing the subject and social content of the professional activities, modeling the systems of relations characteristic of it.

In a business game the integral form of collective educational activity of the model of conditions (the subject context) and interaction with representatives of other role positions (the social context) is realized. The business game should be considered as the highest dimension of the use of the foreign language to teach professional communication because in the process of playing the mastery of business qualities is combined with mastering the techniques of future professional activities. The features of a business game are called the following ones:

1) the presence of a problem that needs to be solved;

2) modeling of a game situation similar to a social profession or scientific problem;

3) the presence of game participants performing game roles;

4) active interaction of players with each other/one another and with the lecturer;

5) the use of additional game attributes;

6) high except the second one are considered characteristic of the role-playing game.

The business game determines the activation of students' thinking activity, positively influencing the development of cognitive skills of future philologists and their professionally significant qualities (competence, creativity, perceptiveness, sociability, optimism, emotional stability), motivates educational and cognitive activities of students, promotes forming valuable attitudes related to the future profession.

As a result, it allows achieving the goals not only of the professional but also of the general development of the personality of the future specialist. One of the methods of stimulating and motivating used in the pedagogical technology of introducing the MEP in the process of forming the PFLC of future philologists is project work. Its purpose is not acquiring knowledge but using, developing, and enriching students' personal experience. Scientists determine the main goals and objectives of project work: a) to teach to acquire knowledge independently, apply it to solve new cognitive and practical problems; b) to promote the formation of students' communication skills; c) to instill the ability to use research techniques: gathering information, analysis of different points of view, to offer hypotheses, the ability to draw conclusions.

These goals and objectives are associated with skills that are indicators of the formation of the PFLC of future philologists according to the communicativecognitive criterion. Considering project work in the context of the objectives of the study, it should be concluded that its application within the considered pedagogical technology promotes the development of cognitive and technological skills of future philologists, the formation of experience of communicative interaction, provides creative potential, students' independence, on the one hand, and on the other hand, allows compensating for the insufficient number of classroom hours devoted to studying a large amount of educational material provided by the program. Among the methods of control and self-control of the effectiveness of the educational cognitive activity of future philologists, it is necessary to single out testing, which is associated with determining the coefficient of the level of education.

According to V. P. Bespalko, one of the most important principles of the pedagogical technology is to diagnose the level of acquirement of learning material30. This indicator shows the availability of knowledge, the formation of relevant skills and abilities. Although the indicators of the PFLC of future philologists are the ability of selfassessment and self-regulation, the pedagogical technology involves using the appropriate forms and methods. It should be noted that the method of self-control involves conscious regulation of the student's activities in order to achieve positive results and to implement the goals set. Selfregulation is carried out in the form of collective (frontal) inspection in combination with control by the lecturer. The method of self-assessment determines the student's critical attitude to his / her abilities and capabilities and objective assessment of the achieved successes. This method involves using answers to questions, presentations such as MEP-control, performing independent tests, and creative works, assessing the formation of the PFLC indicators. The effectiveness of using different teaching methods in combination with the forms largely depends on the teaching aids which are part of the pedagogical process and, accordingly, the suggested pedagogical technology. Under the means of learning, they understand a variety of materials and aids of the educational process, through which more successfully and in a short time the lecturer and students can achieve certain learning goals.

Their basic functions are: informative; assimilation of new material; controlling. In the process of forming the PFLC of future philologists, the MEP and traditional teaching aids are used. Their implementation is regulated by the principles set out, in particular the principle of the integrated use of multimedia teaching aids. The traditional means include textbooks, manuals, audio-, video materials, handouts, works of fiction art, periodicals, as well as the information prepared by the lecturer. The multimedia educational presentations as a means of forming the PFLC of future philologists are classified according to certain criteria and perform various functions in the educational process (informative, representational, organization of the practice of educational material, controlling).

In the context of the study presented, the peculiarity of multimedia presentations as a type of multimedia technologies leads to define the stages of their implementation in the process of forming the PFLC of future philologists. Taking into account the stage nature of organizing the educational-cognitive activity, and considering the MEP as a kind of visual aid, the following technological stages have been identified: 1) previewing; 2)

viewing; 3) post-viewing. They are aimed at achieving a specific pedagogical goal and ensure the effectiveness of the selected structural elements. Each of them has its own tasks. The first stage, pre-view, aims at updating the students' previous experience, the possibility of its application in performing certain tasks, leveling difficulties (lexical, grammatical, phonetic) that hinder the general understanding of the presented material.

The purpose of exercises and tasks used at this stage is to prepare students for viewing the MEP: updating previous experience; presenting and assimilating unfamiliar linguistic, linguistic-regional, and socio-cultural information, increasing interest in new material, awareness of its significance for the future profession, etc. The purpose of the discussion is to arouse interest in the studied topic, to form a positive attitude of future philologists to the new material and the future profession in general. One more example: e. g. Put the following types of schools into two groups and write down ages next to each school: public school, comprehensive school, infant school, junior school, grammar school, preparatory school, pre-preparatory school (the MEP "British School System"). The purpose of the task is to neutralize the lexical difficulties associated with understanding the information contained in the presentation, update the background socio-cultural knowledge.

The second stage, viewing, involves familiarization, study, and assimilation by students of the content of educational material, formation of relevant skills, and perfectibility of abilities. Exercises while watching the video are aimed at developing the skills of listening to English-language messages. Their purpose is to provide understanding the content of the message, as well as focusing on the most important points of the speech product presented, the main characters, the development of the plot.

These are exercises for notation, filling in sentences, tables, etc.: e. g. While watching the video, make a list of the author's predictions about schools of the future (the MEP "School of the Future"). This stage requires the use of basic teaching and learning methods (demonstration, explanation, organization, and participation in training). The search for new forms of organization of the process of professional foreign language training for future philologists, the need to introduce new learning technologies, including accumulating-transferred one, must take into account modern requirements for constructing the educational process and students' psychology.

Thus, at the viewing stage, it should be used the form of individual work. This type of activity not only contributes to forming the skills and

abilities of individual acquisition of knowledge in future philologists, which is important for continuing education throughout further working activities, but also has important educational value, as it promotes the development of such professionally significant qualities of the future specialist as competency, individuality, and stimulates the development of cognitive and professional motives. At the post-viewing stage, the generalization of the studied material, its inclusion in the general system of knowledge and skills of future philologists, the analysis and correction of results of educational and cognitive activity from the point of view of achievement of the set purposes is carried out.

It should be noted that in the process of work there is a development of other components of the studied innovation, associated with the immediate purpose of the suggested pedagogical technology. Because of this, the result of the process of forming PFLC of future philologists using the MEP is achieving the goal of technology – the formed components of the PFLC, which is diagnosed by using criteria and their indicators.

2.3. Method Of Application Of YouTube In Conducting Integrated Lessons Of Natural And Mathematical Cycle Of Basic Secondary Education In The School

Informatization, digitalization and globalization as the driving processes of development of modern society are rapidly spreading in the educational space. The popularity of media resources among students and teachers gives us reason to believe that the use of video hosting will become an integral part of the educational process.

The use of the latest technologies in the XXI century is not just a whim, a requirement of the time, one of the key competencies of a modern teacher. The worldview of the modern generation is changing rapidly, students need new forms and methods in learning. In order to meet the needs of the modern student, teachers are increasingly resorting to innovation in the educational process. In today's world, video is used not only for entertainment, but also for teaching and education. In the last few years, the use of video in lessons, especially integrated ones, has increased significantly due to the increase in educational content on various video hosting services. Integrated lessons of the natural-mathematical cycle with the involvement of video

materials have a lot of advantages. This is the gamification of learning, and interactivity, and improving the technological literacy of students, and the implementation of communicative-activity and individual approaches, and, most importantly, a great tool for motivation.

The use of YouTube video hosting requires a special role. Thousands of videos appear on this service every day, giving teachers the opportunity to use them during different stages of the lesson. However, the correct use of video content requires appropriate methodological training, developed a system of tasks and exercises, training of students, without which the usual viewing will not have an educational and cognitive nature.

Ralph Tyler, a major figure in American education in the twentieth century, described subject integration as a "horizontal relationship of curricula," and he considered such connections important for learning. His claims were based on research on eight-year curriculum for students in 30 high schools in the 1930 years. Researchers then found that students studied well in those high schools that filled the curriculum not only with individual subjects, but also with courses on general topics related to disciplines68.

Presenting main material. Everyone's activities are associated with a large number of psychological factors. Psychologists claim that the use of video materials in the educational process significantly improves the final results and much more motivates students to learn. Taking into account the interest of students in social networks (Instagram, Facebook, TikTok), which are for them the most spectacular and able to arouse interest and maintain attention for a long time, psychologically justify the use of video in integrated lessons of natural sciences in the New Ukrainian School.

Using video clips, we encourage human visual and auditory centers to influence the process of learning and memorizing material. The use of videos is also used as a means of harmonizing the relationships, goals, intentions, ideas, opinions of all participants in the educational process. Such harmonization ensures the preservation of their emotional perception of educational reality and response to this reality, which ensures the creation of an optimal psychological climate for learning and achieving the best results. This process is called neurolinguistic programming in psychology and was first developed in the 70s of the twentieth century by American researchers R. Bandler and J. Grindler. These psychoanalysts have concluded that the basis of any learning process should be an emotional factor that either encourages students to acquire knowledge, or produces in them a strong motive for

confrontation. During the research of O. Yu. Koval and K. V. Melnyk, students were interviewed about which video on YouTube they like to watch during the integrated lessons of the natural mathematical cycle. The results are shown in the diagram. As can be seen from the chart, the vast majority of respondents prefer to watch video clips, animated videos, popular science films, which indicates the great popularity of YouTube video hosting among elementary school students. YouTube is a powerful tool for preparing videos for science and math lessons, as well as an indispensable means of motivation. The effectiveness of activities in the classroom with the use of innovative technologies depends primarily on well-being in the socio-psychological aspect. The student will be interested if he is not afraid of the atmosphere of the lesson, which consists of various aspects of his own.

Activities and activities of the teacher, if the lesson does not criticize his personality by the teacher or classmates, and comments are constructive and relate primarily to the results of his activities. He feels safe if any of his contributions to the learning process are valued. Only in the absence of fear of the new that the teacher offers, the student will allow himself to experiment with patterns of behaviour, finding the optimal result of their behaviour, determining their role in working together, choosing and forming their position, their point of view, constructing their knowledge. As in other spheres of social life, in the education system, innovation processes are not just the introduction of something new. They are implemented as purposeful changes in goals, conditions, content, means, methods, forms of activity, which are characterized by novelty, high potential for efficiency in general or in certain areas, the ability to provide long-term benefits, consistency with other innovations.

The modern system of education is aimed at forming a highly educated, intellectually developed personality with a holistic view of the world, with an understanding of the depth of connections, phenomena and processes in the surrounding reality. Subjective disunity is one of the reasons for the fragmentation of the worldview of a school graduate, while in the modern world the tendencies to economic, political, cultural, information integration prevail. Our time is characterized by the integration of sciences, the desire to get as accurate an idea of the general picture of the world. Mastering the technique of transferring knowledge about one subject while mastering another makes the analytical and synthetic activities of students purposeful, increases the effectiveness of independent methods of work, provides a remarkable organization of mental activity and, finally, produces a

logical sequence in performing both general and specific tasks. Integrated lessons pursue the goal of developing figurative thinking of the student. The integrated lesson combines blocks of knowledge from different subjects, topics around one problem in order to informationally and emotionally enrich the perception, thinking, feelings of the student, which allows to learn a phenomenon in many ways, to achieve the integrity of knowledge. It is aimed at revealing the general laws, ideas, theories reflected in various sciences and their corresponding subjects.

This lesson provides students with a holistic system of ideas about the dialectical-materialist laws of knowledge of the world around them in their relationship and interdependence, and contributes to the deepening and expansion of students' knowledge, the range of their practical application. Such lessons develop analytical abilities and ingenuity, have great educational potential and lead to the disclosure of creative potential in students74. Integration is focused on preparing the student for life in modern society, for a decent choice of their own life and professional position; promotes the development of creativity, communication skills. It promotes the development of a scientific style of thinking, allows students to widely use the scientific method of cognition.

This forms a comprehensive approach to the subject, the only point of view from the point of view of the natural sciences on a problem that will reflect the objective connections in the world around. The scientific foundations of this pedagogical technology are laid in the works of I. P. Pavlov and I. M. Sechenov. Later, psychologists, after analyzing the features of thinking and memory, concluded that the learning process should be designed to form in students the ability to reproduce previously acquired knowledge for strong memorization of new material. Objects and phenomena are interconnected both in nature and in human memory. Interdisciplinary connections make it possible to consider an object or phenomenon from different angles and on the basis of intersystem associations to remember them well 75.

The most important characteristics of memorization are the methods of semantic grouping of educational material, the separation of semantic reference points and the semantic relationship of new material with the already known. Thus, mastering the technique of transferring knowledge about one subject while mastering another makes students' analytical and synthetic activities purposeful, increases the efficiency of independent methods of

work, provides excellent organization of mental activity and, finally, produces a logical sequence in performing both general and specific tasks.

The technology of conducting an integrated lesson can be different. It depends on the goals, objectives, content of the lesson, methods of activity, situations that arise in the process. Traditionally, it is as follows: the message of the topic, acquainting students with the goals and objectives of the lesson, introductory speech of the teacher (student), communication teachers and students, comments, additions, mastering, reviewing, summarizing the lesson.

Not only subject teachers prepare for the lesson, but also students who write essays, select material for individual reports, messages, illustrations, presentations, videos, etc. An important role in improving the efficiency of the integrated lesson is played by its educational and technical equipment (demonstration materials and devices, materials for experiments, observations, audiovisual aids, tables, graphs, diagrams, algorithms, instructions, simulators, multimedia equipment, etc.). Therefore, such lessons are held with special impact in the classrooms, where the maximum conditions for the perception and assimilation of new material are created. These are classrooms of computer science, geography, biology, physics, mathematics, chemistry. To date, there are many services with video content for the preparation of integrated lessons of natural sciences and mathematics.

However, there are certain selection criteria: - the interest of the audience; - relevance of the content; - video duration; - presence or absence of accompanying supports. When selecting a video for an integrated lesson, keep in mind that the content of the content corresponds to the topic of the disciplines in which the lesson is conducted. As an example, we can cite a fragment of an integrated lesson of geography and computer science in 7th grade with the topics "General characteristics of the climate of Eurasia" and "Creating diagrams. Analysis of the data presented in the diagram. At the stage of motivation of educational and cognitive activities, students are invited to watch videos from YouTube "Interesting facts about the climate"(accessmode:https://www.youtube.com/watch?v=BV90I9Uhe2s&t=168s), as well as "Global Climate Change" (access mode: https://www.youtube.com/watch?v=TSiDG70Wsn4). At the stage of learning new material, students are shown the video "Climate-forming factors" (access mode:https://www.youtube.com/watch?v=bZwq_1FptlM).

It should be noted that in the institutes of postgraduate pedagogical education, teachers recommend students to implement elements of ICT in their lessons. They not only recommend, but also work out the method of

using the YouTube video host 79. Conclusions. In the course of the research, we found that the number of videos on YouTube is sufficient for use in integrated lessons of the natural sciences and mathematics cycle. However, when preparing for these types of lessons, teachers should carefully consider the algorithm for using video hosting at different stages of the lesson. Also, do not forget about the oversaturation of the integrated lesson with video materials, as too many of them can distract students from the main topic.

2.4. Peculiarities Of The Organization Of The Educational Process Using Electronic Textbooks

Creation and organization of educational courses using electronic means, especially on the basis of Internet technologies, is a complex technological and methodological task. At the same time, the high labor costs of electronic means are not compensated by their efficiency, due to their rapid obsolescence. Nevertheless, the industry of computer educational and methodological materials is expanding due to the demand for them and their social significance. In this connection, the development of a concept for the construction and use of computer means, in particular electronic textbooks (open education, distance education, etc.), is relevant. Among the computer means of education, electronic textbooks have become the most popular, which make it possible to realize the functions of teaching, self-study, demonstration of educational material, training, control, self-control, and systematization.

Zaimutdinova L. According to Kh.: "An electronic textbook is a complex educational program that ensures the continuity and completeness of the didactic process of teaching, which is a theoretical material, provides training and learning activities and control of the level of knowledge, as well as an information-search function, mathematical and imitation modeling with computer visualization and service functions during interactive feedback." An electronic textbook - unlike a "paper textbook" - is a tool for teaching and learning, its structure and content depend on its goals and use. It is both a tutor, a trainer and a self-taught. It acquires special importance when used in telecommunication systems. Many teachers associate the use of electronic textbooks with the intensification of the educational process, which affect: Increasing purposefulness;Strengthening motivation; ᵒ Increasing the informativeness of the educational content; Activation of students' learning

and cognitive activity; Increasing the pace of learning acti vities. An electronic textbook is effective when there is: Quick feedback; A quick way to find the necessary reference information (contextual and optional); Demonstrative examples and models (it tells, shows, explains); Control (self-control, test, training).

The textbook should be flexible, it can be “adjusted” to the individual capabilities of the student. The main thing is that the user activates any channel of information perception: vision, hearing, thinking, etc. And if an electronic textbook allows us to present educational information “in parallel”, it not only makes learning more intense with all its psychophysical efforts, but also indirectly develops the ability to perceive the world in parallel. Among the advantages of an electronic textbook, the following should be noted: it facilitates the perception of educational material, methods of delivering the material: inductive approach, impact on auditory and emotional memory; allows adaptation in accordance with the student's requirements; frees from huge calculations and allows considering more examples and tasks; allows self-checking at all stages of the work; allows you to beautifully format the work and submit it to the teacher in the form of a file or printout; It has an infinite number of definitions, references, etc.

The importance of electronic textbooks in the modern methodology of teaching technological subjects is of indeterminate importance. This stems from the fact that the information product reflecting the technological process, visually, even virtually, delivered to the student during the teaching process, is the “foundation of creative-constructive activity”. Through the combination of graphic, textual and other types of information intended for students, the student is facilitated to operationally orientate in the content of the process and is given the opportunity to increase his level of knowledge and professional skills, to prepare for future practical activities. Creative-constructive activity, the basis of which is created by the electronic textbook for teaching technological subjects, provides information support for the student’s scientific-methodical activity, improves his professional training, increases perfection and the quality of students’ independent work, and thus implements their self-development and self-education.

The methodological data bank for providing creative-constructive activities is a constructive model of complex informational educational-methodical support, which is implemented in the form of an electronic textbook and accumulated with educational-methodical materials. The content of creative-constructive activities includes: lecture and practical materials,

tests, questions, animated images, a unique design, presentations for practical and lecture materials, a workbook with tasks and examples. The workbook involves individual use, which allows for timely monitoring and the creation of prerequisites for distance learning. The idea of creative-constructive activities in teaching technological subjects is the main content of the electronic textbook, which has methodological value, as it is aimed at increasing the effectiveness of technology lessons. This, in addition to the above, is due to the presence of classical tasks and the theory of their solution in this type of textbook, which is recommended for the development of students' thinking. The student can refer to the glossary available here at any time, where the terms are presented. There is also a workbook intended for individual work of students, in order to consolidate the studied material. It contains: questions, tasks, tests, answers, examples of solving the task, practical tasks. The information system of the electronic textbook for teaching technological subjects provides operational access to a variety of full-text information, which is compiled taking into account the specificity of the subject and easy access for the user; the optimal sequence of actions in the process of independent learning is ensured. Navigation is carried out in an interactive mode and assumes local orientation. The sequence of actions does not exclude the student's voluntary sequence. The main factor that determines the student's comfort in a dialogic interface is its standardization. An important task of the interface, along with standard components, is to display information in such a way that the student's attention is focused on the necessary information at any given moment.

3. TECHNOLOGY IN TRANSFORMING CLASSROOM ACTIVITIES

The infusion and integration of technology in the education process have presented new avenues by which teachers can enrich and enhance teaching and learning activities. However, teachers respond to their use in the classroom setting in a number of ways. First, there are those teachers who fear using any form of technology apart from those with which they are very comfortable (e.g., chalk/chalkboard and printed page). Second, others make use of some form of technology even if they do so infrequently (e.g., overhead projector and videotapes) during class presentations. Third, some teachers maximize the use of different technologies sometimes to the point of overuse during classroom activities. The different ways in which teachers respond to the need to integrate technology in classroom activities may be predicated on their pre-service training and additional encouragement provided in the different educational environments. Many teachers, however, are not prepared to use technology to support their classroom activities.

According to Grabe and Grabe, (1998) approximately fifty percent of teacher-education graduates surveyed felt they were either not prepared or were poorly prepared to use technology. To address some of these deficiencies teachers are provided numerous opportunities to participate in conferences, workshops, and training programs, which serve to encourage them to learn how to use a variety of technology and different ways by which they may be integrated across the curriculum. This journal and others have also been serving a pivotal role in helping teachers to contend with various issues related to the integration of technology to support pedagogy and learning. Articles have not only been geared towards theoretical issues but have also provided examples of practical applications from which teachers can learn and model effective practices as they employ technology in classroom activities.

The increasing application of technology to support teaching and learning provide a basis by which some teachers reconsider the strategies they use in instructional activities. Different strategies are being employed in conjunction with the more familiar ones to accomplish the necessary learning objectives. The strategies adapted have resulted in students playing a greater role in the teaching and learning process. This occurs, as students become more involved in determining the sequence and strategies used in directing

classroom activities. Under the teacher's guidance students are involved in collaborative learning activities. Together teachers and students use different technology to access information, comnmunicate with others in different geographical locations, and explore new instructional media systems. Students are playing a more significant role in classroom activities. Many students are more familiar with some of the technologies employed in the educational environment. Hence, they are often called upon to help both the teacher and other students to understand how the technologies work.

They also show a high level of resourcefulness in determining different ways by which the technologies available might be used to support teaching and learning activities. Working together in this new learning environment, teachers and students become teams of 'knowledge explorers' who translate textbook knowledge into new exciting presentations, using the different technologies (D'Ignazio, 1990c). Consequently, learning for many students become more exciting as they are actively involved in the process.

This dynamic interchange now taking place between and among teachers and students has clearly revolutionized classroom activities. D'Ignazio (1989, 1990a, 1990b), who has written on the application of multimedia systems in educational settings, has used such terms as "knowledge explorers", "knowledge navigators", "teacher explorers", and "student navigators" in describing the various activities in which both teachers and students often engage as they utilize multimedia systems in the classroom. D'Ignazio (1990c) further observed that within this new classroom environment teachers act as process and knowledge specialists. The infusion and integration of technology in classrooms will not only result in the greater use of collaborative learning strategies but also will, as D'Ignazio (1990a) indicated, increase the use of strategies such as thematic teaching, guided inquiry apprenticeship, group problem solving, and critical thinking. These strategies will help to deepen and enhance interpersonal relations in the classroom. The level of interaction between and among teacher and students increases as they work collaboratively to accomplish various learning objectives. Classroom activities will then be less centered on the teacher and can be more focused on the learners.

Lane (1994) noted that the use of electronically mediated instruction (EMI) to duplicate the traditional face-to-face classroom has resulted in a shift from teacher centered to learner-centered classes. In this situation the responsibility for leaming is shifted to the student and the teacher facilitates

the learning by acting as a coach, resource guide, and companion in leaming. Instructional technology does not only encourage teachers and students to work collaboratively but also results in more cooperative learning activities among the students. By working cooperatively, students help each other to understand more about the technology and how to use it to accomplish set learning objectives, thereby increasing the level of interaction between and among them. Under such cond-tions students experience a change from an individual task structure with frequent whole class instruction to a task structure in which they interact in small groups. Thus, facilitating an atmosphere of cooperation rather than competition in the classroom (Slavin, 1980). As efforts are made to get teacher and students to collaborate and cooperate in their classroom activities more and more is heard about a constructivist approach to education. This has led many teachers to embrace a constructivist approach to teaching and learning over and above a directed approach.

The constructivist perspective, which evolved from some branches of thinking in cognitive learning theory, is based on the concept that knowledge is produced by the individual learner rather than processed from information received from an external source. The directed perspective, also referred to as objectivist or behaviorist, is grounded primarily in behaviorist learning theory and the information processing branch of cognitive learning theories and is based on the concept that learning happens when knowledge is transmitted to the learner. Despite the differences between the two perspectives on teaching and learning, they can both be employed to ensure an effective and efficient educational environment. Some uses of technology in teaching and learning are associated with directed instruction (e.g. drill and practice, tutorials) but many other applications (e.g. problem-solving, multimedia applications, telecommunications) can be used to enhance both the directed and the constructivist approaches, depending on how teachers integrate them in classroom activities.

The introduction of new information technology in teaching and learning has impacted the traditional classroom activities. The various technologies generate a greater level of interaction between and among teachers and students. They also help to enhance the educational environment while providing enrichment in the learning experience. However, technology use in the classroom should only be considered appropriate if it is used for specific purposes in the teaching and learning process. Its incorporation in this process should not just be as an appendage, but as an integral part of the

teaching and learning objectives. Employing technology of any kind in the instructional process becomes valuable only when they are seen merely as elements in a well-constructed learning environment (D'Ignazio, 1989). The use of technology, therefore, should be driven by specific objectives related to instruction and learning with direct linkages to the curriculum.

4. ARTIFICIAL INTELLIGENCE IN EDUCATION

Artificial intelligence (AI) is arguably the driving technological force of the first half of this century, transforming virtually every industry, if not all human endeavors in general.

Every new technology goes through a period of intense growth in reputation and expectations, followed by a sharp decline when it inevitably fails to meet expectations, followed by a slow recovery as the technology evolves and becomes more integrated into our lives. As visualized in the Gartner diagram, it can be said that every technology is somewhere on the curve at any given time (for example, deep learning, which is part of AI, is currently at its peak).

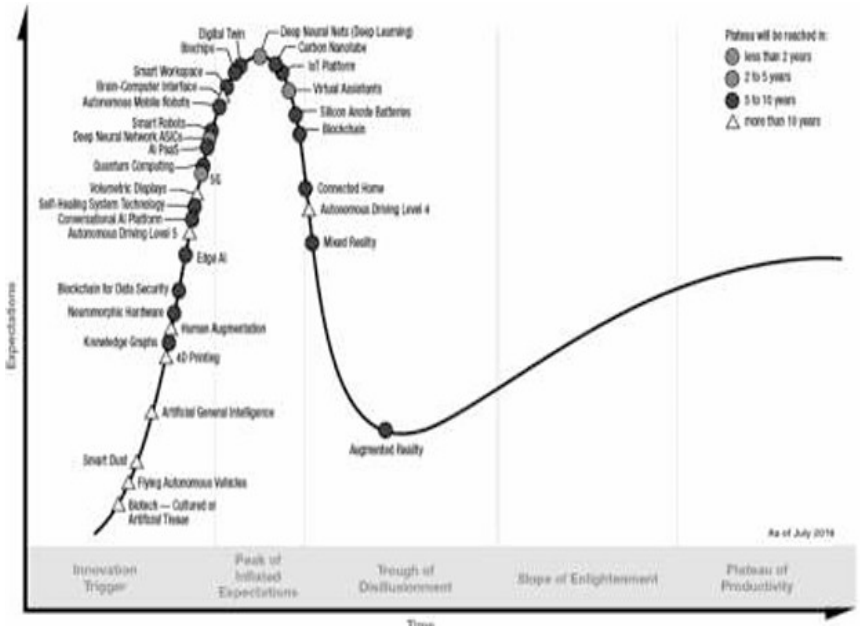


Fig.4.1. Gartner diagram. Source: Gartner Inc. 3

It is widely expected that AI will have an enormous impact on what we teach, as it will impact many occupations. Take for instance the Organization for Economic and Co-operative Development (OECD) Program for the International Assessment of Adult Competencies (PIAAC)5 survey, which measures adults' proficiency in key information processing skills—

literacy, numeracy and problem solving in technology rich environments—and gathers information and data on how adults use their skills at home and at work. Already, AI is matching more than 50% of adult human-proficiency levels, and closing in on another 36%. (Elliott Stuart, "Computers and the Future of Skill Demand).

According to IBM's Leaderboard, AI should be getting into the realm of deeper self-learning by the early 2020s and become capable of assisting, collaborating, coaching and mediating by the early 2030s.

4.1. The How: Promises And Implications Of AI For Teaching And Learning

But of particular interest here, artificial intelligence has also quietly entered the classroom.20 Whether students, teachers, parents and policy makers welcome it or not, so-called intelligent, adaptive, or personalized learning systems are increasingly being deployed in schools and universities21 around the world, gathering and analyzing huge amounts of student big data, and significantly impacting the lives of students and educators.22 However, while many assume that artificial intelligence in education (AIED) means students being taught by robot teachers, the reality is more prosaic yet still has the potential to be transformative.

In fact, AI technologies have been researched in educational contexts for around fifty years.24 More recently, companies as influential as Amazon, Google and Facebook have invested millions of dollars developing AIED products, joining well-established multimillion dollarfunded AIED companies such as Knewton and Carnegie Learning, while the $15 million Global Learning XPrize called for software that empowers children to take control of their own learning (AIED by another name). Meanwhile, AI is being introduced into some mainstream schools as a curriculum in its own right, is being developed to improve online tutoring, and is being researched as a way of enhancing teacher training. In short, the application of AI in educational contexts is growing exponentially, such that by 2024 it is predicted to become a market worth almost $6 billion.

While we may have some limited knowledge or experience of mainstream AI, either from the media or in our daily lives, for many the use of AI in education remains a mystery. A multitude of yet-to-beans were questions spring to mind. How exactly can AI work in classrooms, and what can be achieved? With AI requiring so much data, how is student privacy

maintained? What will be AI's long-term effects on teacher roles? Are the proponents of AIED promising more than can be delivered? What is the impact of AI on student agency and outcomes? And what are the social and ethical consequences? However, we begin with a tentative response to an ostensibly simpler question: what does AIED actually look like?

The Background of AI AI is one of those aspects of modern life about which most of us have some awareness, and yet recognize we have little knowledge.39 In fact, for many AI is synonymous with humanoid robots,40 which might be because news about AI is almost always illustrated with a picture of a robot or a digital brain. However, while robotics (embodied AI, that can move and physically interact with the world) is a core area of AI research, AI is being applied in many different ways and different contexts.

However, first, we should acknowledge that the very name artificial intelligence is sometimes seen as unhelpful. Instead, some researchers prefer augmented intelligence, which retains the human brain as the source of intelligence, and positions the computer and its programs as a sophisticated tool with which humans might enhance or augment our intellectual capabilities. In this approach, computers are employed to do what humans find more difficult (such as finding patterns in huge amounts of data).

The debate contrasting augmented and artificial will inevitably run and run, with artificial intelligence winning at least on popular usage even if augmented intelligence is more accurate or useful.

A 1956 workshop held at Dartmouth College, a US Ivy League research university, is widely considered to be AI's foundational event.41 It was where what is thought to be the first AI program, the Logic Theorist, was presented and discussed. Over the following decades, AI developed in fits and starts with periods of rapid progress (for example, rule-based expert systems) interspaced with periods known as AI winters where confidence and funding all but evaporated. In recent decades, thanks to three key developments (the advent of faster computer processors, the availability of large amounts of big data, and advances in computational approaches) AI has entered a period of renaissance—AI has now become an integral, pervasive, and inescapable, although often hidden, part of our daily lives. In fact, paradoxically, the more that it is integrated, the less we tend to think of it as AI.

Instead, AI is often known as an advanced computer program (such as email spam filtering),43a personal assistant (such as Cortana),44 a recommendation system (such as in Netflix),45 or perhaps a language learning app (such as Duolingo).46 Having said that, recent voice-activated smart

speakers, such as Google Home47 and Amazon Echo,48 have made AI more visible in our living rooms. In fact, many recent developments in AI are both groundbreaking and in many ways transformative. Relatively recent AI computational approaches, such as machine learning (supervised, unsupervised, and reinforcement learning), neural networks (including deep learning), and evolutionary algorithms have all been used in a diverse range of applications.

For example, recent advances in face recognition (ensuring that faces in smartphone photographs are always in sharp focus, and identifying travelers at e-passport gates) are thanks to the application of neural networks and machine learning. Google researchers presented a brain inspired AI neural network with 10 million randomly selected video thumbnails from YouTube. By using deep-learning techniques, and despite not being told how to recognize anything in particular, this machine learning system soon learned how to detect human faces in photographs. Two years later, Facebook introduced a nine-layer deep AI neural network, involving more than 120 million parameters, to identify (not just detect) faces in timeline photographs. It was trained on a dataset of four million images of faces that had previously been labeled by humans (the Facebook users, who had been happily labeling their friends in uploaded photographs over several years).

Another area that has seen much AI development in recent years is autonomous vehicles, with neural networks being used to enable cars, trucks, and taxis to drive without human intervention. A complex rig of cameras and sensors collate massive amounts of real-time data (the road's edges and markings, road signs and traffic lights, other vehicles including bicycles, other potential obstacles, and pedestrians), while a neural network-driven intelligent agent, drawing on massive of computing power, controls the car's steering, acceleration, and braking. A probably less well-known use of AI is in journalism. News organizations around the world are developing AI technologies to support their news gathering and news reporting. For example, AI agents continually monitor global.

Another application of AI is in law, where e-Discovery tools are being used by lawyers to help process the huge amounts of documentation that need to be reviewed as potential evidence in civil or criminal legal cases. One technique involves a machine learning analysis of a sample of documents that have been reviewed and labeled by an expert. The outcomes enable the AI to then identify which of the remaining documents need to be prioritized for in-

depth review. A final brief example is the use of AI in medical diagnoses. For example, AI techniques are used by radiologists to help them identify anomalies in medical images more quickly while making fewer mistakes. One system looks for irregularities in X-ray images. If, for example, it finds nodules on an image of a pair of lungs, it sends it to a pulmonary radiologist for further checks.

4.2. AI Techniques And Terminology

While it is relatively straightforward to understand what the applications of AI outlined in the previous section are doing, understanding how they are doing it can require some highly technical knowledge—exacerbated by the fact that any one AI application might draw on several different AI techniques. This is one reason why many people involved in AI have advanced degrees in mathematics or physics (although AI is increasingly being offered as a service: for example, Amazon's Machine Learning on AWS, Google's TensorFlow, IBM's Watson, and Microsoft's Azure). Nonetheless, because some AI techniques have already been repeatedly mentioned, and because they play important roles in AIED and so will be mentioned again, some key and closely interlinked AI techniques and terminologies will next be introduced.

4.2.1. Algorithms

Algorithms are at the core of AI, such that the history of AI might be thought of as the history of the development of increasingly sophisticated and increasingly efficient (or elegant) algorithms. Probably the most famous algorithm of recent times is PageRank,60 which was developed in 1996 by the founders of Google while they were students at Stanford University. It ranks the relative importance of a website, by counting the number of external links to the website's pages, to determine where the website appeared in a Google search. In fact, all computer programs are algorithms. They comprise hundreds if not thousands of lines of code, representing sets of mathematical instructions that the computer follows in order to solve problems (compute a numerical calculation, grammar-check an essay, process an image, or explain patterns that we see in nature).61 All that makes AI algorithms distinct from other computer programs is that they involve some specific approaches and, as we have noted, they are applied to areas we might think of as essentially

human—such as visual perception, speech recognition, decision-making and learning.

4.2.2. Machine Learning

Much early, rule-based AI involves writing in advance the steps that the computer will take to complete a task, rules that will be followed exactly. Machine learning, on the other hand, is about getting computers to act without being given every step in advance. Instead of the algorithms being programmed exactly what to do, broadly speaking they have the ability to learn what to do. This is not to suggest that machine learning does not require large amounts of programming, because it does. But rather that, instead of direct commands leading to direct outputs, machine learning involves large amounts of input data to predict novel outcomes. Machine learning algorithms analyze the data to identify patterns and to build a model which is then used to predict future values (for example, by identifying patterns in historical stocks data, AI predicts future stock movements; by identifying patterns in photographs of named people, it predicts who is shown in other photographs; and by identifying patterns in medical symptoms, it predicts a specific diagnosis). In other words, machine learning may be considered a three-step process (analyze data, build a model, undertake an action) that is continuously iterated (the outcomes of the action generate new data, which in turn amends the model, which in turn causes a new action). It is in this sense that the machine is learning.

Many recent applications (including natural language processing, selfdriving cars, and the Google DeepMind AlphaGo program that beat the world's number one player of Go)62 have all been made possible thanks to machine learning. In fact, machine learning is so widespread today that, for some commentators, AI and machine learning have become synonymous—whereas machine learning is more properly a sub-field of AI. What is true, however, is that the renaissance and exponential growth of AI over the last decade, has come about because of significant advances in machine learning (based on, as we have noted, faster computer processors, the availability of large amounts of big data, and new computational approaches). There are three main categories of machine learning: supervised, unsupervised, and reinforcement learning.

4.2.3. Application Of ML In Distance Learning

Distance learning is one area where ML has had a significant impact in enhancing aspects of personalization, administrative tasks, and analytics, but it has not been without significant challenges. Based on the evaluation of the outcomes of ML in this respect, one gets a somewhat mixed picture of how efficient this technology is in enhancing learning performance and tackling inequality in learning environments.

First, it can develop a unique lesson plan with content and speed according to students' capabilities. Therefore, adaptive learning systems use reinforcement learning and Bayesian knowledge tracing algorithms to provide the students with a learning environment that adapts to the student's performance and interactivity. For example, ML in adaptive learning systems monitors the student's interaction with the studied material and highlights their "blind spots"; based on this information, the system will customize the content presented to the student. This can involve better engagement and learning in general, as the students will receive instructions customized to their learning paths (Figure 4.2).

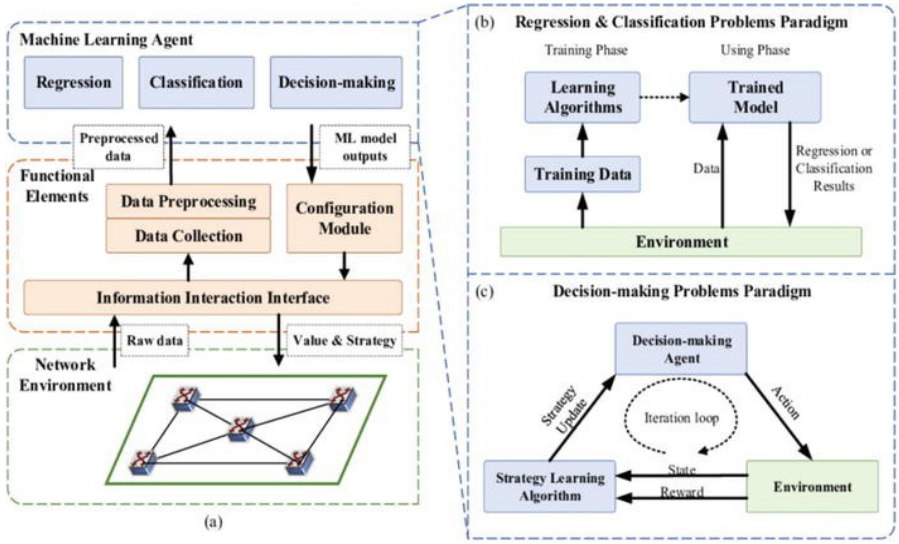


Figure 4.2. How machine learning can engage with students learning patterns for a differentiated experience.

In conclusion, machine learning has radically transformed distance learning, and, as a result, universities such as Taibah can allow students living anywhere on the planet to get the best education on the Internet. This is because machine learning offers personalized learning experiences, engages learners, and applies real-time analytics, bolstering distance education success. Nevertheless, the challenges in developing machine learning for education are evident; however, its potential to create a new learning experience is challenging to overlook, subsequently shaping the future of internet communication. Thus, recognizing the challenges in distance education is crucial to appreciating the vast advantages of using ML in the process. Challenges like data privacy, bias, and the requirement for strong technical support will always be there. However, one has to emphasize the significance of the human factor's presence in the educational process. Moving forward, there are great possibilities for enhancing the educational system with the help of ML. New patterns like AI-based tutorial facilities and the individualized learning environment have the potential to increase students' outcomes even more. However, ethical issues must be the focus when these technologies advance and this will require further research. On the future work, more studies should be carried out on establishing sound and fair ML models, data protection, and closing the digital gap to optimize the benefits of this disruptive technology.

4.2.4. Reinforcement Learning

In some senses, reinforcement learning is the most powerful of the machine learning categories. In both supervised and unsupervised learning, the model derived from the data is fixed, and if the data changes the analysis has to be undertaken again (in other words, the algorithm is run once more). However, reinforcement learning involves continuously improving the model based on feedback—in other words, this is machine learning in the sense that the learning is ongoing. The AI is provided with some initial data from which it derives its model, which is evaluated, assessed as correct or incorrect, and rewarded or punished accordingly (to use a computer game metaphor, its score is increased or reduced).

The AI uses this positive or negative reinforcement to update its model and then it tries again, thus developing iteratively (learning and evolving) over time. For example, if an autonomous car avoids a collision, the

model that enabled it to do so is rewarded (reinforced), enhancing its ability to avoid collisions in the future. Artificial Neural Networks An artificial neural network is an AI algorithm that is based on the structure and functions of biological neural networks (i.e. animal brains), that might be applied in advanced supervised, unsupervised, or reinforcement learning. Our brains are made up of billions of individual neurons, each of which is connected to as many as a thousand other neurons, giving trillions of connections. Memory is thought to emerge from complex combinations of these connections across the brain, while learning is thought to involve the strengthening of those connections.

Although artificial neural networks have been trained to do some incredible things (such as identifying faces in moving crowds of people), they remain primitive in comparison to higher-order animal brains. Unlike for example the human brain's billions of neurons, they usually involve only a few thousand neurons (in some exceptional cases, a few million).

Finally, the impressive results of neural networks and other machine learning technologies should not beguile us: A neural network of today no more "learns" or "reasons" about the world than a linear regression of the past. They merely induce patterns through statistics. Those patterns may be opaquer, more mediated and more automatic than historical approaches and capable of representing more complex statistical phenomena, but they are still merely mathematical incarnations, not intelligent entities, no matter how spectacular their results.68

4.3. How AI Works In Education

Having established a working understanding of AI, we will now look in more detail at how AI works in educational contexts, beginning with a brief history. However, what will not be discussed but what might nonetheless have a major impact on education is the use of AI to support school administration (system-facing AI that addresses things like class timetabling, staff scheduling, facilities management, finances, cybersecurity, safety and security).69 Our focus is the use of AI to support learning (student- and teacher-facing AI).

Precursors of the application of AI in education can be found in the work of the psychologists Sidney Pressey, who was a professor at Ohio State University in the 1920s, and B. F. Skinner, known as the father of

behaviorism, who was a professor at Harvard University from 1948 until his retirement in 1974. For Pressey, the challenge was to leverage the potential of multiple-choice tests to consolidate student learning as well as to evaluate it. Drawing on Edward Thorndike's law of effect,70 he argued that, for tests to support learning, immediate feedback was essential—which is not usually possible when tests are marked by hand. However, a mechanical approach could ensure that no learning opportunities were missed.

Skinner's teaching machine might be thought to have also foreshadowed something else later taken up by AI in education researchers, dividing automated teaching into separate components (in Skinner's case, distinguishing between the subject content, which was pre-programmed into the machine, and the student's achievements, whether or not they answered a question correctly). However, although in a sense Skinner's teaching machine was responsive to individual students, it could not be considered adaptive. That is to say, it did not adapt either the questions, or the order in which they were presented, according to the achievements or needs of the individual students. Instead, question delivery was pre-scripted. While a student could proceed at their own pace, they went through the same list of questions as every other student and in the same order.

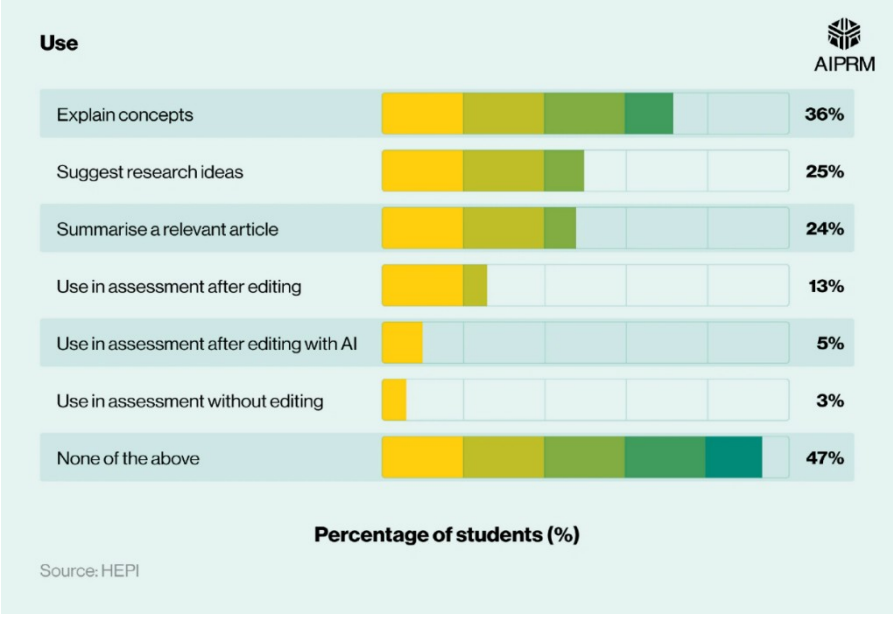


Figure 4.3. A breakdown of how students use AI in higher education

Further research from HEPI also found that:

- More than a third (35%) of students who have used generative AI aren't aware of how often it produces made-up facts, stats, or citations (known as 'hallucinations').
- Two-thirds (66%) of students consider it acceptable to use generative AI for explaining concepts, but only 3% think it's acceptable to use it for text in assessments without editing.
- Three in 10 students (30%) agree that their institution should provide AI tools, with fewer than one in 10 (9%) saying they currently do.
- Just over a fifth (22%) of students are satisfied with the support they receive on AI, with around three-fifths (62%) feeling neutral on the matter.
- Almost three-quarters (73%) expect to use AI once they graduate. The majority believe they will use it to translate text (38%), followed by enhancing written content (37%) and summarizing text (33%)

4.4. Attitudes Towards AI In The Education Sector

- As of 2024, just over half (52%) of people surveyed by YouGov felt that primary schools (K-12) should focus on teaching students how to use AI appropriately – a slight decrease of 2% from 2023.

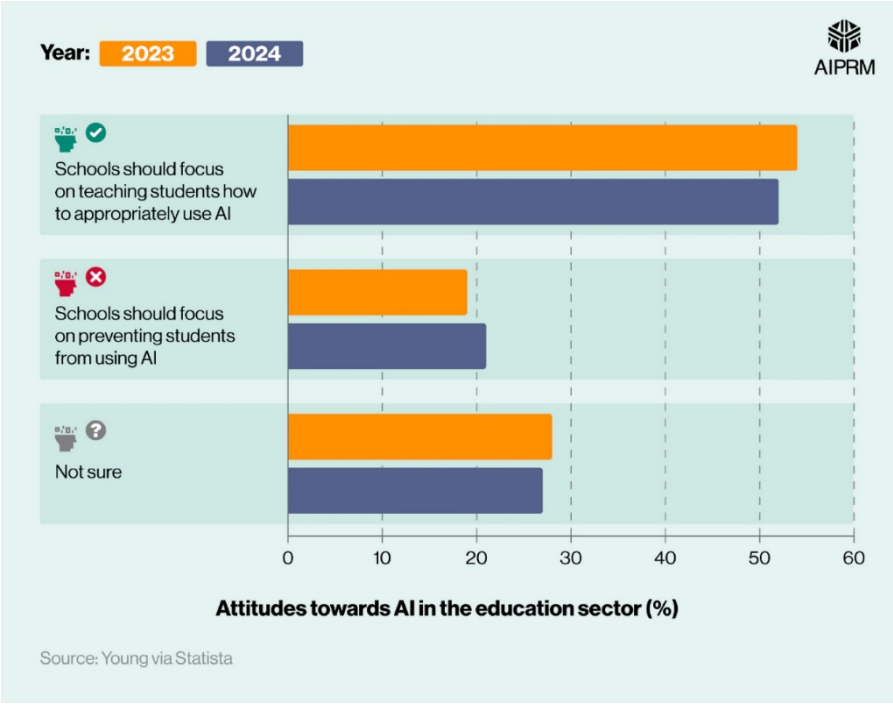


Figure 4.4. A breakdown of attitudes towards AI in the education sector

While the overall majority feel that schools should be concentrating on the appropriate use of AI with younger students, just over a fifth (21%) felt that primary schools should instead be focusing on preventing students from using AI – a 2% rise from 2023 figures.

4.5. Adaptive Learning

Also working in the 1950s, Norman Crowder, who was interested in communication rather than psychology, devised a paper-based alternative to the early teaching machines, known as intrinsic or branching programmed instruction.74 In Crowder's system (which he developed for training U.S. Air Force engineers to find malfunctions in electronic equipment), the user is presented with a short page of information followed by a multiple-choice question, with each possible answer directing the student to a new page. If the correct answer was chosen, the new page would present new information, building upon that which was correctly understood; if an incorrect answer was

chosen, the new page would contain feedback designed to help the student understand the cause of their error, based on what the student had chosen. The system might also branch through one or two additional pages of corrective materials before returning the student back to the main pages. In short, Crowder's system adapted the pathway through the teaching materials according to the individual student's developing knowledge, such that each student might see quite different sets of pages.

However, a British polymath, Gordon Pask, probably developed the first truly adaptive teaching machine in the early 1950s. Known as SAKI (the self-adaptive keyboard instructor), it was designed for trainee keyboard operators learning how to use a device that punched holes in cards for data processing.75 What distinguished SAKI from the other early teaching machines was that the task presented to a learner was adapted to the learner's individual performance, which was represented in a continuously changing probabilistic student model.

4.6. Computer-Aided Instruction

SAKI went through many iterations, taking advantage of developments in computers and the new microprocessors, and was one of the first adaptive systems to be commercialized. However, over the following years, other than in the various iterations of SAKI, adaptive learning made few advances, and the focus shifted to what became known as computer-aided instruction (CAI) systems. The 1960s and 1970s saw many CAI systems being built, an early influential example being PLATO (programmed logic for automatic teaching operations), which was developed at the University of Illinois. PLATO involved students accessing standard teaching materials, some of which were interactive, on a central mainframe computer via remote terminals, with as many as a thousand students working at the same time.

This system was also notable for being the first to introduce in an educational technology many tools and approaches still common today, such as user forums, email, instant messaging, remote screen-sharing, and multiplayer games. Around the same time, Stanford University and IBM developed a computer-aided instruction system that was made available via remote terminals to a few local elementary schools. This system involved a linear presentation of teaching materials, for mathematics and language arts, together with drill and practice activities. A third prominent example was

TICCIT (time-shared interactive computer controlled information television), developed by Brigham Young University, which was used to teach freshman-level mathematics, chemistry, physics, English, and various language courses. Each subject area was broken down into topics and learning objectives, which in turn were represented as screens of information. TICCIT then provided a predetermined sequence, although learners could also use the keyboard to navigate through the screens in any order that they found helpful.

How CAI could become adaptive to the needs of individual students, and whether the application of techniques from AI might be useful. The first implementation of AI techniques in computer-aided instruction is usually credited to Jaime Carbonell, who, in his 1970 PhD thesis, introduced a system called SCHOLAR. This novel system was designed to enable a student to review their knowledge of the geography of South America, by means of a dialogue using a subset of English. SCHOLAR was qualitatively different from standard CAI because, unique for the time, it was capable of generating individual responses to student statements by drawing from a semantic network (a way of representing knowledge, in this case knowledge of geography, in which concepts are linked according to their semantic relationships).

A SCHOLAR dialogue might look something like this: SCHOLAR: Use one of the following: Sucre, French, Argentina, Spanish, to answer the question: What is the language in Chile? SCHOLAR: You are taking too much time... Student: *Spanich* SCHOLAR: You should have written “Spanish.” Very good. Although by today’s standards the dialogue (and especially its pedagogy) appears primitive, SCHOLAR is usually considered to be the first example of what came to be known as Intelligent Tutoring Systems, to which we turn next.

5. APPLICATIONS OF AI IN EDUCATION INTELLIGENT

So-called intelligent tutoring systems (ITS) are among the most common applications of AI in education (in any case, as we have seen, they have probably been around the longest). Generally speaking, ITS provide stepby-step tutorials, individualized for each student, through topics in welldefined structured subjects such as mathematics or physics.82 Drawing on expert knowledge about the subject and about pedagogy, and in response to individual student's misconceptions and successes, the system determines an optimal step-by-step pathway through the learning materials and activities. As the student proceeds, the system automatically adjusts the level of difficulty and provides hints or guidance, all of which aim to ensure that the student is able to learn the given topic effectively.

ITS come in many shapes, although typically they involve several AI models, an approach that we will unpack here. As we saw in our earlier discussion of AI technologies, AI models are highly simplified computational representations (in semantic networks, as used by SCHOLAR, in ontologies,83 or in knowledge graphs)84 of specific knowledge about the real world (just like a model car is a simplified representation of a real car). The models used by ITS represent knowledge specific to teaching and learning. Typically, knowledge about the topic to be learned is represented in what is known as a domain model, knowledge about effective approaches to teaching is represented in a pedagogical model, and knowledge about the student is represented in a learner model.85 The ITS algorithm draws on these three models in order to adapt a sequence of learning activities for each individual student. A fourth model found in some ITS is the open learner model.

5.1. Examples Of Artificial Intelligence In Education

5.1.1. Smart Content

"Smart content" creation, from digitized guides of textbooks to customizable learning digital interfaces, are being introduced at all levels, from elementary to post-secondary to corporate environments.

Content Technologies, Inc., an artificial intelligence development company specializing in automation of business processes and intelligent instruction design, has created a suite of smart content services for secondary education and beyond. Cram101, for example, uses AI to help disseminate and breakdown textbook content into digestible "smart" study guide that includes chapter summaries, true-false and multiple choice practice tests, and flashcards. JustTheFacts101 has a similar, though more streamlined purpose — highlighting and creating text and chapter-specific summaries, which are then archived into a digital collection and made available on Amazon.

Other companies are creating smart digital content platforms, complete with content delivery, practice exercises, and real-time feedback and assessment. Netex Learning, for example, allows educators to design digital curriculum and content across devices, integrating rich media like video and audio, as well as self- or online-instructor assessment. Nextex also provides a personalized learning cloud platform designed for the modern workplace, in which employers can design customizable learning systems with apps; gamification and simulations; virtual courses; self assessments; video conferencing; and other tools. Learning platforms for the modern workplace are designed to allow employees to master additional skills and receive continuous and automated feedback, and when used strategically have the potential to help improve performance and increase production.

5.2. Intelligent Tutoring Systems

Mastery learning, a set of principles largely tied to the work of Educational Psychologist Benjamin Bloom in the 1970's, supports the effectiveness of individualized tutoring and instruction in the classroom. Curriculum organized around a student's progress, combined with timely targeted feedback, immediate opportunities for corrected practice, and enrichment activities, are fundamental mastery learning practices. Developing a one-on-one tutoring system that can provide these elements has been a coveted goal of AI researchers since the 1970's and 1980's.

Intelligent tutoring systems (ITS) have made much progress since their early counterparts. Though today's systems, as articulated by Chaudhri, et al., (2013), are not quite at the "two-sigma effect" (i.e. two grade levels) of

human tutors, there's evidence to suggest that ITS systems perform as well, if not better, than individual human tutors for many students.

Carnegie Learning's "Mika" software, for example, uses cognitive science and AI technologies to provide personalized tutoring and real-time feedback for post-secondary education students, particularly incoming college freshman who would otherwise need remedial courses. Carnegie states the cost of such remedial learning as costing colleges $6.7 billion annually, with only a 33% success rate for math courses. ITS provides the potential for students to more conveniently access flexible and more personalized modes of learning on an ongoing basis.

5.2.1. The Domain Model

A domain model represents knowledge about the subject that the ITS aims to help the students learn (much like the subject knowledge in a standard, non-educational, expert system). This might, for example, be knowledge about mathematical procedures, genetic inheritance, or the causes of World War I. In fact, over the years, mathematics for primary and secondary school students has dominated ITS. Mathematics, along with physics and computer science, are AIED's low-hanging fruits because they are, at least at a basic level, well-structured and clearly defined.

5.2.2. The Pedagogy Model

The ITS pedagogy model represents knowledge about effective approaches to teaching and learning that have been elicited from teaching experts and from research in the learning sciences (although it should be acknowledged that some ITS developers falsely assume that they have sufficient expertise in pedagogy).86 Pedagogical knowledge that has been represented in many ITS include knowledge of instructional approaches,87 the zone of proximal development,88 interleaved practice,89 cognitive load,90 and formative feedback.91 For example, a pedagogical model that implements Vygotsky's zone of proximal development will ensure that activities provided by the system to the student are neither too easy nor too challenging, one that implements individualized formative feedback will ensure that feedback is provided to the student whenever it might support the student's learning.

5.2.3. The Learner Model

As we have seen, some CAI effectively (although usually by another name) implemented versions of both domain and pedagogical models: knowledge of what was to be learned and knowledge of how to teach what was to be learned (for example, using linear or branching programmed instruction). However, what distinguishes AI-driven ITSs is that, as foreshadowed by Pask's SAKI, they also include a learner model: "a representation of the hypothesized knowledge state of the student." In fact, many ITS incorporate a wide range of knowledge about the student—such as their interactions, material that has challenged the student, their misconceptions, and their emotional states while using the system—all of which can be used to inform what is being taught and how, together with what support needs to be provided and when. In fact, most ITSs go much further.

The knowledge stored about the individual student is augmented with knowledge of all the students who have used the system so far, from which the system machine learns in order to predict which pedagogical approach and which domain knowledge is appropriate for any particular student at any specific stage of their learning. It is the learner model that enables ITS to be adaptive, and the machine learning that makes this adaptivity especially powerful.

Insight: AI Systems Enable New Forms of Interaction AI models allow computational processes to make recommendations or plans and also enable them to support forms of interaction that are more natural, such as speaking to an assistant. AI enabled educational systems will be desirable in part due to their ability to support more natural interactions during teaching and learning. In classic edtech platforms, the ways in which teachers and students interact with edtech are limited.

Teachers and students may choose items from a menu or in a multiple-choice question. They may type short answers. They may drag objects on the screen or use touch gestures. The computer provides outputs to students and teachers through text, graphics, and multimedia. Although these forms of inputs and outputs are versatile, no one would mistake this style of interaction with the way two people interact with one another; it is specific to human-computer interaction. With AI, interactions with computers are likely to become more like human-to-human interactions (see table 2).

A teacher may speak to an AI assistant, and it may speak back. A student may make a drawing, and the computer may highlight a portion of the

drawing. A teacher or student may start to write something, and the computer may finish their sentence—as when today's email programs can complete thoughts faster than we can type them. Additionally, the possibilities for automated actions that can be executed by AI tools are expanding. Current personalization tools may automatically adjust the sequence, pace, hints, or trajectory through learning experiences.

Actions in the future might look like an AI system or tool that helps a student with homewor or a teaching assistant that reduces a teacher's workload by recommending lesson plans that fit a teacher's needs and are similar to lesson plans a teacher previously liked. Further, an AI-enabled assistant may appear as an additional "partner" in a small group of students who are working together on a collaborative assignment.

An AI-enabled tool may also help teachers with complex classroom routines For example, atool may help teachers with orchestrating23 the movement of students from a full class discussion into small groups and making sure each group has the materials needed to start their work.

Table 2. Differences that teachers and students may experience in future technologies.

	Familiar Technology Capabilities	Future Technology Capabilities
Input	• Typing	• Speaking
	• Clicking and dragging	• Drawing
	• Touching and gesturing	• Analyzing images and video
Processing	• Displaying information and tasks	• Assisting students and teachers
	• Sequencing learning activities	• Planning and adapting activities
	• Checking student work	• Revealing patterns in student work
Output	• Text	• Conversations
	• Graphics	• Annotating and highlighting
	• Multimedia	• Suggesting and recommending
	• Dashboards	• Organizing and guiding

Many have experienced a moment where technology surprised them with an uncanny ability to recommend what feels like a precisely personalized product, song, or even phrase to complete a sentence in a word processor such as the one being used to draft this document. Throughout this supplement, we talk about specific, focused applications where AI systems may bring value (or risks) into education. At no point do we intend to imply that AI can replace a teacher, a guardian, or an educational leader as the custodian of their students' learning. We talk about the limitations of models in AI and the conversations that educational constituents need to have about what qualities they want AI models to have and how they should be used.

5.3. AI Enables Adaptivity In Learning

Adaptivity has been recognized as a key way in which technology can improve learning. AI can be a toolset for improving the adaptivity of edtech. AI may improve a technology's ability to meet students where they are, build on their strengths, and grow their knowledge and skills. Because of AI's powers of work with natural forms of input and the foundational strengths of AI models (as discussed in the What is AI? section), AI can be an especially strong toolkit for expanding the adaptivity provided to students. And yet, especially with AI, adaptivity is always more specific and limited than what a broad phrase like "meet students where they are" might suggest. Core limits arise from the nature of the model at the heart of any specific AI-enabled system. Models are approximations of reality. When important parts of human learning are left out of the model or less fully developed, the resulting adaptivity will also be limited, and the resulting supports for learning may be brittle or narrow. Consequently, this section on Learning focuses on one key concept: Work toward AI models that fit the fullness of visions for learning—and avoid limiting learning to what AI can currently model well. AI models are demonstrating greater skills because of advances in what are called "large language models" or sometimes "foundational models."

These very general models still have limits. For example, generative AI models discussed in the mainstream news can quickly generate convincing essays about a wide variety of topics while other models can draw credible images based on just a few prompts. Despite the excitement about foundational models, experts in our listening sessions warned that AI models are narrower than visions for human learning and that designing learning

environments with these limits in mind remains very important. The models are also brittle and can't perform well when contexts change. In addition, they don't have the same "common sense" judgment that people have, often responding in ways that are unnatural or incorrect.26 Given the unexpected ways in which foundational models miss the mark, keeping humans in the loop remains highly important. Intelligent Tutoring Systems: An Example of AI Models One long-standing type of AI-enabled technology is an Intelligent Tutoring System (ITS).

In an early success, scientists were able to build accurate models of how human experts solve mathematical problems. The resulting model was incorporated into a system that would observe student problem solving as they worked on mathematical problems on a computer. Researchers who studied human tutors found that feedback on specific steps (and not just right or wrong solutions) is a likely key to why tutoring is so effective. For example, when a student diverged from the expert model, the system gave feedback to help the student get back on track. Importantly, this feedback went beyond right or wrong, and instead, the model was able to provide feedback on specific steps of a solution process. A significant advancement of AI, therefore, can be its ability to provide adaptivity at the step-by-step level and its ability to do so at scale with modest cost.

As a research and development (R&D) field emerged to advance ITS, the work has gone beyond mathematics problems to additional important issues beyond step-by-step problem solving. In the early work, some limitations can be observed. The kinds of problems that an ITS could support were logical or mathematical, and they were closed tasks, with clear expectations for what a solution and solution process should look like. Also, the "approximation of reality" in early AI models related to cognition and not to other elements of human learning, for example, social or motivational aspects. Over time, these early limitations have been addressed in two ways: by expanding the AI models and by involving humans in the loop, a perspective that is also important now.

Today, for example, if an ITS specializes in feedback as a student practices, a human teacher could still be responsible for motivating student engagement and self-regulation along with other aspects of instruction. In other contemporary examples, the computer ITS might focus on problem solving practice, while teachers work with students in small groups. Further, students can be in the loop with AI, as is the case with "open learner

models”—a type of AI-enabled system that provides information to support student self-monitoring and reflection.

Important Directions for Expanding AI-Based Adaptivity Adaptivity is sometimes referred to as “personalization.” Although this is a convenient term, many observers have noted how imprecise it is. For some educators, personalization means giving learners “voice and choice,” and for others it means that a learning management system recommends an individual “playlist” of activities to each student. Hidden in that imprecision is the reality that many edtech products that personalize do so in limited ways. Adjusting the difficulty and the order of lesson materials are among the two most common ways that edtech products adapt. And yet, any teacher knows there is more to supporting learning than adjusting the difficulty and sequence of materials. For example, a good teacher can find ways to engage a student by connecting to their own past experiences and can shape explanations until they really connect in an “aha!” moment for that student. When we say, “meet the learner where they are,” human teachers bring a much more complete picture of each learner than most available edtech. The teacher is also not likely to “over personalize” (by performing like an algorithm that only presents material for which the learner has expressed interest), thereby limiting the student’s exposure to new topics. The nature of “teachable moments” that a human teacher can grasp is broader than the teachable moments today’s AI models grasp. In our listening sessions, we heard many ways in which the core models in an AI system must be expanded.

AI models cannot be fully equitable while failing to recognize or build upon each student’s sources of competency. AI models that are more asset-oriented would be an advance. 2. From individual cognition to including social and other aspects of learning. The existing adaptivity rhetoric has also tended to focus on individualized learning and mostly on cognitive elements of learning, with motivational and other elements only brought in to support the cognitive learning goals. Attendees observe that their vision for learning is broader than cognition. Social learning is important, for example, especially for students to learn to reason, explain, and justify. For students who are learning English, customized and adaptive support for improving language skills while learning curricular content is clearly important. Developing self-regulation skills is also important. A modern vision of learning is not individualistic; it recognizes that students learn in groups and communities too.

From neurotypical to neurodiverse learners. AI models could help in including neurodiverse learners (students who access, process, and interact with the world in less common ways than “neurotypical” students) who could benefit from different learning paths and from forms of display and input that fit their strengths. Constituents want AI models that can support learning for neurodiverse learners and learners with disabilities. Thus, they want AI models that can work with multiple paths to learning and multiple modalities of interaction. Such models should be tested for efficacy, to guard against the possibility that some students could be assigned a “personalized” but inadequate learning resource. In addition, some systems for neurodiverse students are presently underutilized, so designs that support intended use will also be important.

From fixed tasks to active, open, and creative tasks. As mentioned above, AI models are historically better at closed tasks like solving a math problem or logical tasks like playing a game. In terms of life-wide and lifelong opportunities, we value learning how to succeed at open-ended and creative tasks that require extended engagement from the learner, and these are often not purely mathematical or logical. We want students to learn to invent and create innovative approaches. We want AI models that enable progress on open, creative tasks.

From correct answers to additional goals. At the heart of many adaptivity approaches now on the market, the model inside the technology counts students' wrong answers and decides whether to speed up, slow down, or offer a different type of learning support. Yet, right and wrong answers are not the only learning goals. We want students to learn how to self-regulate when they experience difficulties in learning, for example, such as being able to persist in working on a difficult problem or knowing how and when to ask for help. We want learners to become skilled in teamwork and in leading teams. As students grow, we want them to develop more agency and to be able to act on their own to advance toward their own learning goals. Listing every dimension of expansion that we heard in our listening sessions is beyond the scope of this report. Some additional dimensions are presented in the following sections on Teaching, Assessment, and Research. For example, in Research, we discuss all the ways in which AI systems have trouble with context—context that humans readily grasp and consider.

Overall, constituents in the listening sessions realized we need an ambitious outlook on learning to respond to the future today’s learners face. Constituents were concerned about ways in which AI might narrow learning.

For example, if the incorporation of AI into education slowed attention to students' skills on creative, open-ended tasks and their ability to lead and collaborate in teams, then school districts may be less able to realize their students' progress in relation to a Portrait of a Graduate who excels in communication and other skills valued in communities and careers.

Learning With and About AI As AI is brought into schools, two broad perspectives about AI in education arise: (1) AI in support of student learning; and (2) support for learning about AI and related technologies. So far, we've discussed AI systems and tools to support student learning and mastery of subjects like mathematics and writing. Yet, it is also important that students learn about AI, critically examine its presence in education and society, and determine its role and value in their own lives and careers. We discuss risks across each section in this report. Here, it is important for students to become more aware of and savvy to the risks of AI—including risks of bias and surveillance—as they appear in all elements of their lives. In the recent past, schools have supported students' understanding of cybersecurity, for example. AI will bring new risks, and students need to learn about them.

We are encouraged by efforts we've seen underway that would give students opportunities to learn about how AI works while also giving them opportunities to discuss relevant topics like privacy and security.33 Other learning goals are noted in the K-12 Computer Science Framework. We've seen that students can begin learning about AI in elementary, middle, and high school. They can use AI to design simulations and products that they find exciting. And we've seen that students want to talk about the ethics of products they experience in their everyday lives and have much to say about the kinds of products they'd like to see or not see in school. (And later, in the Research section, we note the desire for co-design processes that involve students in creating the next generation of AI-enabled edtech).

Overall, it's important to balance attention to using AI to support learning and giving students opportunities to learn about AI. A Challenge: Systems Thinking About AI in Education As AI expands into the educational system, our listening session attendees reminded us that it will be entering parts or locations of the system that are presently dysfunctional. AI is certainly not a fix for broken systems, and instead, must be used with even more care when the systems' context is unstable or uncertain.

As discussed previously, because AI systems and tools do not fully align with goals for learning, we have to design educational settings to situate

AI in the right place, where educators and other adults can make effective use of these tools for teaching and learning. Within the ITS example, we saw that AI could make learning by practicing math problems more effective, and a whole curricular approach might include roles for teachers that emphasize mathematical practices like argumentation and modeling. Further, small-group work is likely to remain important: Students might work in small groups to use mathematics to predict or justify as they work on responding to a realistic challenge.

At the present, one "right place" for people, and not AI, is understanding how learning can be culturally responsive and culturally sustaining, as AI is not even close to being ready to connect learning to the unique strengths in a student's community and family. Open Questions About AI for Learning With advances occurring in the foundations for AI, opportunities to use AI in support of learning are rapidly expanding.

As we explore these opportunities, the open questions below deserve ongoing attention: ● To what extent is AI enabling adaptation to students' strengths and not just deficits? Is AI enabling improved support for learners with disabilities and English language learners?

● How are youth voices involved in choosing and using AI for learning?

● Is AI leading to narrower student activities (e.g., procedural math problems), or the fuller range of activities highlighted in the National Educational Technology Plan (NETP), which emphasizes features such as personalized learning, project-based learning, learning from visualizations, simulations, and virtual reality, as well as learning across school, community, and familial settings?

● Is AI supporting the whole learner, including social dimensions of learning such as enabling students to be active participants in small group and collaborative learning? For example, does AI contribute to aspects of student collaboration we value like shared attention, mutual engagement, peer help, self-regulation, and building on each other's contributions?

● When AI is used, are students' privacy and data protected? Are students and their guardians informed about what happens with their data?

● How strong are the processes or systems for monitoring student use of AI for barriers, bias, or other undesirable consequences of AI use by learners? How are emergent issues addressed?

● Is high-quality research or evaluations about the impacts of using the AI system for student learning available? Do we know not only whether the system works but for whom and under what conditions?

Always Center Educators in Instructional Loops To succeed with AI as an enhancement to learning and teaching, we need to always center educators (ACE). Practically speaking, practicing "ACE in AI" means keeping a humanistic view of teaching front and center. ACE leads the Department to confidently respond "no" when asked "will AI replace teachers?" ACE is not just about making teachers' jobs easier but also making it possible to do what most teachers want to do. That includes, for example, understanding their students more deeply and having more time to respond in creative ways to teachable moments. To bring more precision to how and where we should center educators, we return to our advocacy for human in the loop AI and ask, what are the loops in which teachers should be centered? Figure 1 suggests three key loops (inspired by research on adaptivity loops34):

The loop in which teachers make moment-to-moment decisions as they do the immediate work of teaching. The loop in which teachers prepare for, plan, and reflect on teaching, which includes professional development. The loop in which teachers participate in decisions about the design of AI-enabled technologies, participate in selecting the technologies, and shape the evaluation of technologies—thus setting a context for not only their own classroom but those of fellow teachers as well.

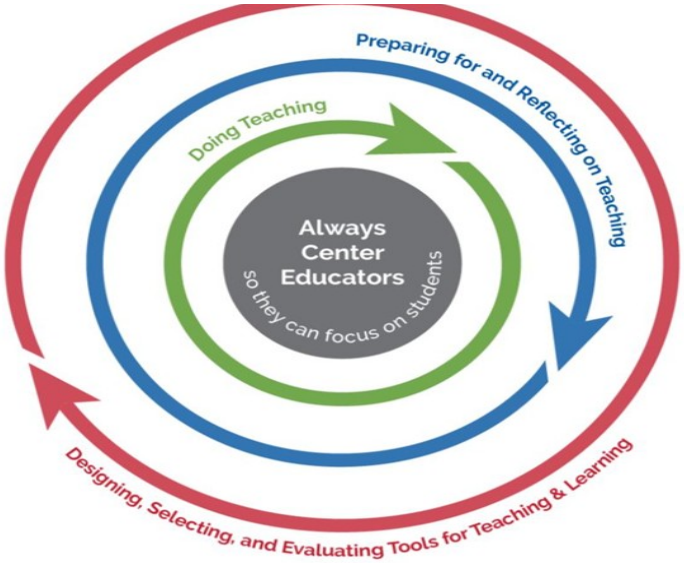


Figure 5.1: Three ways to center educators as we conceptualize human in the loop AI.

Formative Assessment, we also discuss teachers' important role in feedback loops that support students and enable school improvement. That section also includes a discussion of the concepts of "bias" and "fairness," which are important to teachers. Insight: Using AI to Improve Teaching Jobs The job of teaching is notoriously complex, with teachers making thousands of decisions each day. Teachers participate in classroom processes, in interactions with students beyond classrooms, in work with fellow teachers, and in administrative functions. They also are part of their communities and thus are expected to interact with families and caregivers.

Preparing and Supporting Teachers in Planning and Reflecting ACE also means preparing teachers to take advantage of possibilities like those listed above and more. In the Research section, we highlight how pre-service education still tends to compartmentalize and inadequately address the topic of technology. That section suggests a need to invest in research about how to deeply integrate technology in pre-service teacher training programs. In-service teachers, too, will need professional development to take advantage of opportunities that AI can provide, like those presented in the Teaching section. Professional development will need to be balanced not only to discuss opportunities but also to inform teachers of new risks, while providing them with tools to avoid the pitfalls of AIBy nature, teaching requires significant time in planning as well to account for the breadth of needs across their rosters —especially for inclusive learning environments and students with IEPs and 504 plans.

AI could help teachers with recommendations that are tuned to their situation and their ways of practicing teaching and support with adapting found materials to fit their exact classroom needs. For students with an IEP, AI could help with finding components to add to lesson plans to fully address standards and expectations and to meet each student's unique requirements. Even beyond finding components, AI might help adapt standardized resources to better fit specific needs—for example, providing a voice assistant that allows a student with a visual difficulty to hear material and respond to it or permitting a group of students to present their project using American Sign Language (ASL) which could be audibly voiced for other students using an AI ASL-to-Spoken-English translation capability.

Indeed, coordinating IEPs is time-consuming work that might benefit from supportive automation and customized interactivity that can be provided

by AI. Reflection is important too. In the bustle of a classroom, it is sometimes difficult to fully understand what a student is expressing or what situations lead to certain positive or negative behaviors. Again, context is paramount. In the moment, teachers may not be aware of external events that could shape their understanding of how students are showing up in their classrooms. Tools that notice patterns and suggest ways to share information might help students and teachers communicate more fully about strengths and needs.

Designing, Selecting, and Evaluating AI Tools The broadest loop teachers should be part of is the loop that determines what classroom tools do and which tools are available. Today, teachers already play a role in designing and selecting technologies. Teachers can weigh in on usability and feasibility. Teachers examine evidence of efficacy and share their findings with other school leaders. Teachers already share insights on what is needed to implement technology well. While these concerns will continue, AI will raise new concerns too. For example, the following Formative Assessment section raises concerns about bias and fairness that can lead to algorithmic discrimination.

Those concerns go beyond data privacy and security; they raise attention to how technologies may unfairly direct or limit some students' opportunities to learn. A key takeaway here is that teachers will need time and support so they can stay abreast of both the well-known and the newer issues that are arising and so they can fully participate in design, selection, and evaluation processes that mitigate risks.

Carry on with that work somewhat independently. Professor Inge Molenaar40 has wondered about the challenges of control in a hybrid teaching scenario: When should a teacher be in control? What can be delegated to a computational system? How can a teacher monitor the AI system and override its decisions or take back control as necessary? Figure 8: The tension between human and AI decision making: Who is in control?

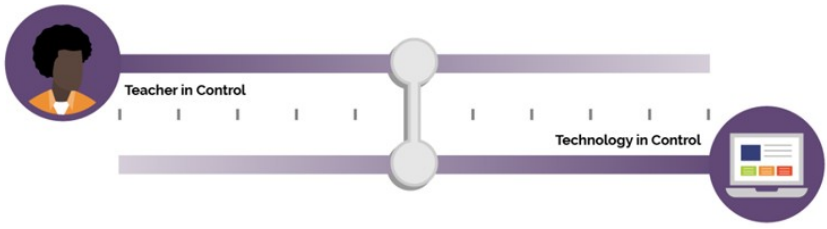


Figure 5.2. expresses the tension around control.

To the left, the teacher is fully in control, and there is no use of AI in the classroom. To the right, the technology is fully in control with no teacher involved—a scenario which is rarely desirable. The middle ground is not one dimensional and involves many choices.

Molenaar analyzed products and suggests some possibilities:

- The technology only offers information and recommendations to the teacher.
- The teacher delegates specific types of tasks to the technology, for example, giving feedback on a particular math assignment or sending out reminders to students before an assignment is due.
- The teacher delegates more broadly to the technology, with clear protocols for alerts, for monitoring, and for when the teacher takes back control. These and other choices need to be debated openly. For example, we may want to define instructional decisions that have different kinds of consequences for a student and be very careful about delegating control over highly consequential decisions (for example, placement in a next course of study or disciplinary referrals). For human in the loop to become more fully realized, AI technologies must allow teacher monitoring, have protocols to signal a teacher when their judgment is needed, and allow for classroom, school, or district overrides when they disagree with an instructional choice for their students.

We cannot forget that if a technology allows a teacher choice—which it should—it will take significant time for a teacher to think through and set up all the options, requiring greater time initially. Challenge: Making Teaching Jobs Easier While Avoiding Surveillance We also recognize that the very technologies that make jobs easier might also introduce new possibilities for surveillance (Figure 3). In a familiar example, when we enable a voice assistant in the kitchen, it might help us with simple household tasks like setting a cooking timer. And yet the same voice assistant might hear things that we intended to be private.

This kind of dilemma will occur in classrooms and for teachers. When they enable an AI-assistant to capture data about what they say, what teaching resources they search for, or other behaviors, the data could be used to personalize resources and recommendations for the teacher. Yet the same data might also be used to monitor the teacher, and that monitoring might have consequences for the teacher. Achieving trustworthy AI that makes teachers' jobs better will be nearly impossible if teachers experience increased

surveillance. A related tension is that asking teachers to be "in the loop" could create more work for teachers if not done well, and thus, being in the loop might be in tension with making teaching jobs easier. Also related is the tension between not trusting AI enough (to obtain assistance) or trusting it too much (and incurring surveillance or loss of privacy). For example, researchers have documented that people will follow instructions from a robot during a simulated fire emergency even when (a) they are told the robot is broken and (b) the advice is obviously wrong.41 We anticipate teachers will need training and support to understand how and when they will need to exercise human judgement.

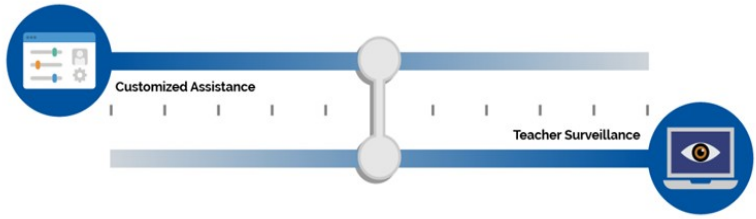


Figure 5.3. Highly customized assistance vs. increased teacher surveillance

Challenge: Responding to Students' Strengths While Protecting Their Privacy Educators seek to tackle inequities in learning, no matter how they manifest locally (e.g. in access to educational opportunities, resources, or supports). In culturally responsive and culturally sustaining approaches, educators design materials to build on the "assets"—individual, community, and cultural strengths that students bring to learning.

Along with considering assets, of course, educators must meet students where they are, including both strengths and needs. AI could assist in this process by helping teachers with customizing curricular resources, for example. But to do so, the data inputted in an AI-enabled system would have to provide more information about the students. This information could be, but need not be, demographic details. It could also be information about students' preferences, outside interests, relationships, or experiences.44 What happens to this data, how it is deleted, and who sees it is of huge concern to educators. As educators contemplate using AI-enabled technologies to assist in tackling educational inequities, they must consider whether the information about

students shared with or stored in an AI-enabled system is subject to federal or state privacy laws, such as FERPA.

Further, educators must consider whether interactions between students and AI systems create records that must be protected by law, such as when a chatbot or automated tutor generates conversational or written guidance to a student. Decisions made by AI technologies, along with explanations of those decisions that are generated by algorithms may also be records that must be protected by law. Therein, a third tension emerges, between more fully representing students and protecting their privacy (Figure5. 4).

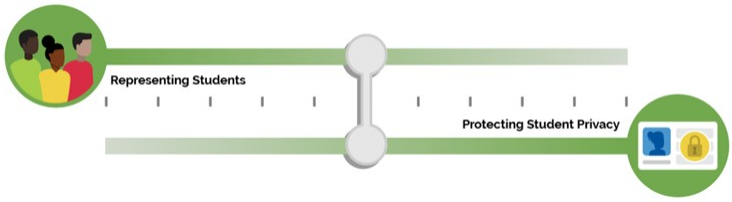


Figure 5.4. Responding to students' strengths while fully protecting student privacy

Further, representation would be just a start toward a solution. As discussed earlier in this report, AI can introduce algorithmic discrimination through bias in the data, code, or models within AI enhanced edtech. Engineers develop the pattern detection in AI models using existing data, and the data they use may not be representative or may contain associations that run counter to policy goals. Further, engineers shape the automations that AI implements when it recognizes patterns, and the automations may not meet the needs of each student group with a diverse population. The developers of AI are typically less diverse than the populations they serve, and as a consequence, they may not anticipate the ways in which pattern detection and automation may harm a community, group, or individual. AI could help teachers to customize and personalize materials for their students, leveraging the teacher's understanding of student needs and strengths.

It is time consuming to customize curricular resources, and teachers are already exploring how AI chatbots can help them design additional resources for their students. An elementary school teacher could gain powerful supports for changing the visuals in a storybook to engage their students or for adapting language that poorly fits local manners of speaking or even for

modifying plots to incorporate other dimensions of a teacher's lesson. In the Learning section, we noted that AI could help identify learner strengths. For example, a mathematics teacher may not be aware of ways in which a student is making great sense of graphs and tables about motions when they are in another teacher's physics classroom and might not realize that using similar graphs about motion could help with their linear function lesson. AI might help teachers when they seek to reflect student strengths by creating or adapting instructional resources.

Yet, the broad equity challenges of avoiding algorithmic discrimination while increasing community and cultural responsiveness must be approached within the four foundations we earlier outlined: human in the loop, equity, safety and effectiveness, and evaluation of AI models. We cannot expect AI models to respect cultural responsiveness.

The Department is particularly concerned that equity is something that engaged educators and other responsive adults are in the best position to address and something that is never solely addressable as a computational problem. Questions Worth Asking About AI for Teaching As leaders in both pre-service and post-service teacher education contemplate how AI can improve teaching (along with policymakers, developers, and researchers), we urge all in the ecosystem to spend more time asking these questions:

- Is AI improving the quality of an educator's day-to-day work? Are teachers experiencing less burden and more ability to focus and effectively teach their students?
- As AI reduces one type of teaching burden, are we preventing new responsibilities or additional workloads being shifted and assigned to teachers in a manner that negates the potential benefits of AI?
- Is classroom AI use providing teachers with more detailed insights into their students and their strengths while protecting their privacy?
- Do teachers have oversight of AI systems used with their learners? Are they exercising control in the use of AI-enabled tools and systems appropriately or inappropriately yielding decision-making to these systems and tools?
- When AI systems are being used to support teachers or to enhance instruction, are the protections against surveillance adequate?
- To what extent are teachers able to exercise voice and decision-making to improve equity, reduce bias, and increase cultural responsiveness in the use of AI-enabled tools and systems? Key

Recommendation: Inspectable, Explainable, Overridable AI In the Introduction, we discuss the notion that when AI is incorporated into a system, the core of the AI is a model. In the Learning section, we discuss that we need to be careful that models align to the learning we envision (e.g., that they aren't too narrow). Now, based on the needs of teachers (as well as students and their families/caregivers), we add another layer to our criteria for good AI models: the need for explain ability.

Some AI models can recognize patterns in the world and do the right action, but they cannot explain why (e.g., how they arrived at the connection between the pattern and the action). This lack of explain ability will not suffice for teaching; teachers will need to know how an AI model analyzed the work of one of their students and why the AI model recommended a particular tutorial, resource, or next step to the student. Thus, explain ability of an AI system's decision is key to a teacher's ability to judge that automated decision. Such explain ability helps teachers to develop appropriate levels of trust and distrust in AI, particularly to know where the AI model tends to make poor decisions.

Explain ability is also key to a teacher's ability to monitor when an AI system may be unfairly acting on the wrong information (and thus may be biased. We discuss bias and fairness more in the Assessment section next). Surrounding the idea of explain ability is the need for teachers to be able to inspect what an AI model is doing. For example, what kinds of instructional recommendations are being made and to which students? Which students are being assigned remedial work in a never ended loop? Which are making progress? Dashboards in current products present some of this information, but with AI, teachers may want to further explore which decisions are being made and for whom and know of the student-specific factors that an AI model had available (and possibly which factors were influential) when reaching a particular decision. For example, some of today's adaptive classroom products use limited recommendation models that only consider student success on the last three mathematics problems and do not consider other variables that a teacher would know to consider, such as whether a student has an IEP Plan or other needs. Our call for attending to equity considerations as we evaluate

AI models requires information about how discriminatory bias may arise in particular AI systems and what developers have done to address it. This can only be achieved with transparency for how the tools use datasets to achieve outcomes and what data they have available or that a teacher could

include in her judgement but are not available to the system (IEP status is offered as an example above). Teachers will also need the ability to view and make their own judgement about automated decisions, such as decisions about which set of mathematics problems a student should work on next. They need to be able to intervene and override decisions when they disagree with the logic behind an instructional recommendation.46 Teachers need protection against adverse ramifications when they assert human judgement over an AI system's decision.

6. SOCIAL SOFTWARE IN FORMAL EDUCATION

The use of social software for personal reasons challenges educators used to having control over the tools used in their programs. Social software, unlike institutionally-based learning management systems (LMS), is often either not owned by the educational institution or incorporates elements that come from beyond it, is focused on individuals and their relationships rather than courses, and is under the control of these users, not teachers. In most current instances, social software applications have not been designed specifically for students enrolled in formal education programs. Rather, students join social networks for personal reasons, motivated by a desire to expand and enrich their social lives. Thus, a central challenge of this book is to help educators both understand social software use and equip them with the knowledge and skill to use educational software in formal courses and as doors to lifelong learning opportunities for themselves and their students. To date, much social software use has focused on building communities in parallel or outside of formal education. For example, sites such as Facebook support communities of students enrolled or at least interested in a particular university or school.

These groups often contain thousands of members and are used for discussions and announcements about special activities, providing a way to connect users who share a common interest in that particular institution—or at least its social life. We believe that these tools are too important and powerful to be excluded from the formal curriculum, that they can be used to support and encourage learning in all subject domains. In addition, the use of social software applications in formal education encourages and supports learners with lifelong learning skills that they will be able to apply beyond their graduation from any formal education program.

Finally, social software develops “the kinds of skills needed to meet the challenge of earning a living in the twenty-first century—flexibility, adaptability, collaborativeness and problem-solving prowess—bear a one-to-one congruence with the constellation of skills and outlooks needed to engage in every other key participation opportunity related to human capacity development”.

MOOCs Recent years have seen a massive growth in MOOCs (Massive Open Online Courses), with courses from organizations like edX, Coursera, Udacity, and others gaining tens of thousands of participants. Their

forebears, starting with CCK08—a connectivist course with a few thousand users —remain intensive in their use of social software, and could not run without extensive networked technologies such as Twitter, blogs, and social aggregation platforms. While many popular MOOCs employ predominantly instructivist approaches to teaching, they also provide tools for social interaction—as a result, a large ecosystem of social groups and networks has sprung up around them, with learners helping one another, exchanging ideas, and learning together in more or less formal groupings.

Social Software in Informal Learning Non-formal and informal intentional learning outstrips formal learning in both time spent on the activity and the number of people engaged in it many times over, and has always done so. Tough's research (1979) in the 1970s suggested that adults typically spent around 200 hours every year on intentional learning activities. In 2000, Livingstone found that Canadian adults spent considerably more time on informal learning than formal, in the area of 15 hours per week. Were these research studies to be repeated today, this amount of time may be considerably higher. Google's search engine is used by over 85% of Internet users and whenever someone performs a search, it is usually in order to learn something or be reminded of something that they already know. Perhaps it would be more accurate to say that, in keeping with connectivist precepts, people know that the knowledge they seek resides in the network—even if they often do not need to retain it—but, in one way or another, they are seeking knowledge. In other words, Google Search is a learning technology and, by any measure, the most widely used distinct learning technology product in the world.

While language and books are undoubtedly more important learning technologies, there is no single book or language that reaches a wider audience than Google Search. Meanwhile, Wikipedia, its nearest competitor as a learning technology, receives close to 10 million visits an hour to its English-language site alone, with nearly 8 billion page views of over 4 million articles produced by tens of thousands of editors, over 33,000 articles described as "active", which means having had five or more edits per year. Wikipedia gets further millions of visitors to its simplified English-language and Chinese sites, with billions of visitors to other sites using less commonplace languages. But Google Search and Wikipedia are just the tip of a massive iceberg of informal and nonformal learning that is enabled by the social web. Sites such as StackOverload, Answers.com, Lifehacker, How Stuff Works, Instructables, as well as millions of YouTube videos and thousands of less well-known sites

provide more or less formal instruction to millions of people every day. Twitter, Facebook, and Google+ are rich sources of knowledge and information, providing simple questions and answers for study groups, reading groups, and collaborators. Despite the pointless trivia that often passes through it, the social web can be appreciated as a web of learning.

The Many Purposes of Educational Social Software Social software functions in many ways and is as divergent in forms, systems, and software packages as it is in the interest and skills of users. However, Mejias (2005) argues that social software serves two purposes. The first is to manage ever-larger sets of social relationships, such that meaningful and functional social relationships can be built and effective communications can be maintained despite the numbers, distances, or time barriers that separate them. Second, social software affords us opportunity to create and support more intimate and authentic relationships between our closest friends, families, and colleagues. It also helps us to build social confidence, and sometimes, new relationships. Ellison, Steinfield, and Lampe (2007) have found that Facebook usage is associated with increased formation of social capital, especially for those with low self-esteem and lower life satisfaction. They also found that both bonding social capital (strengthening relationships with those whom one already has a primary relationship) and bridging social capital (weaker, more extended relationships with others) were associated with increased use of Facebook.

These direct social uses are important, but they are by no means the only ways that social software can provide value to learners. The social net creates an ecology “involving not only technologies but also other people, values, norms and social contexts”. This enables a learner to construct knowledge by seeing his or her place in the world, and hence grasping connections not just with other people but also with the world itself. An obvious benefit that is not addressed by Mejias’s classifications is that social software systems enable learners to create content, find answers to questions, make and receive challenges, and provide opportunities to see the world differently. A less obvious benefit is that social software can be used to aggregate the opinions, beliefs, and discoveries of many people in order to guide us through our learning journeys with little or no direct social interaction at all. Social software is not just social glue but an enabler of the creation, discovery, and presentation of new knowledge. Other people have many roles to play in the learning process, not just in the construction of factual or procedural knowledge.

From an educational perspective, social software can, for instance, enable users to:

- Provide helpful resources
- Help them move into the next zone of proximal development
- Solve problems
- Create more complex artifacts
- Present multiple perspectives and enrich connections
- Model different ways of thinking
- Explore ethical problems
- Learn to work with others
- Connect ideas from different perspectives and fill in gaps to connect existing ideas.

6.1. Social Learning Theories

When this context is changed by pedagogical intervention, technological affordances, social expectations, or a host of other variables, one can expect change in learning effectiveness or efficiency. Social learning—especially in its cyber-enhanced forms—has evolved in a context of rapid change, and many of its proponents are champions of this. However, the formal institutional structures where most of these changes take place are noted more for their resistance to change and defence of tradition, than for the capacity for rapid or emergent adaptation (Bates, 2005; Winner, 1997). Thus online learning has long been engulfed in controversy, and there has been considerable jockeying among those with a vested interest in either change or the status quo. While this tension will and probably should never be fully resolved, we believe that dedicated educators often share underlying assumptions about teaching and learning. This section is designed to explicate the rationale for social learning and expose both its promises and shortcomings.

Social Learning The defining component of social learning is the presence and participation of other learners and, at least in formal education, a teacher. In this section we will outline the theoretical and empirical evidence indicating how and why the presence of others makes a difference to both teaching and learning. Until recently, most literature on social learning assumed that the interaction between participants takes place face-to-face, and

often in a classroom, laboratory, or other structured context. However, recent pedagogical literature, especially from distance education and e-learning perspectives often assumes an electronically mediated context for teaching and learning. It is natural to wish to compare the online and face-to-face alternatives. When considered overall, studies reveal no significant difference in learning outcomes between activities and courses that are taken at a distance and those in the classroom. This is not too surprising because it is possible to use any learning technology well or badly, regardless of the type. It makes no more sense to ask whether people learn better at a distance or face-to-face than to ask whether pictures drawn in pencil are better than ones painted with oils. They are different technologies that can produce both excellent and atrocious results.

That aside, the reliability of most studies that show the benefits of technology to learning are dubious, conflating many different factors. However, it is likely that the constraints and affordances of communication and information technologies, especially factors related to the limits of the media, scale, distance, and time, do effect how we learn from and with each other.

At the very least, pedagogies and technologies are intertwined in a dance, where the moves of one determine the moves of the other. In our three-generation model, we have divided the generations of developments in distance learning into three distinct pedagogical eras; at the time of writing, the third generation is still emerging. We consider each generation to be partly determined by the communication and processing tools available, and partly by the popular pedagogies of the period, noting that changes in each one alters the adjacent possibilities and thus both the affordances and uses of the other. This codependency between tools and pedagogies is inevitable: until there are the means for cheap, rapid forms of many-to-many dialogue, for example, it is very hard to design distance learning experiences that require peer debate. Distance education was not a viable option at all until the advent of reliable and affordable technologies of production like the printing press, and communication systems such as a postal service.

Although we describe each generation as an historical sequence, this does not mean that previous generations have faded away or vanished. As Kelly (2010) has observed, technologies seldom, if ever, die. As new pedagogical models emerge, they do not replace what came before, though they may become more dominant than those they supersede. Not only is it possible to find large numbers of fairly pure examples of older approaches

being used today, the newer generations incorporate the older ones in their assemblies so previous generations of pedagogy have become, if anything, more popular than they were when first adopted. These are the three generations that we have identified as emerging so far:

1. Behaviourist/cognitivist: pedagogies of instruction ;
2. Social constructivist: pedagogies of construction;
3. Connectivist: pedagogies of connection.

Social Learning Theories The poet John Donne's proclamation that no man is an island suggests our deep interdependence with others. It is an interesting but perhaps irresolvable debate as to which came first—whether it was the emergence of self from the family or tribal origins, or whether society emerged from the aggregation of many selves. Even when we are working alone, our language, metaphors, thoughts, and feelings are guided and created through the use of signs, symbols, and expressions that we have acquired from others.

John Dewey's colleague and fellow pragmatist George Herbert Mead is most remembered for his notions of how a sense of self can only arise through discourse with others. He notes how "we are in possession of selves just in so far as we can and do take the attitude of others towards ourselves and respond to those attitudes" . But Mead goes even further, arguing that in interaction and cooperative work with others, the giving and taking of directions and advice allows us to develop critical forms of empathy to create appropriate and viable images of ourselves. He argues that "in giving directions to others, he gives them to himself, and thus arouses a similar response in himself which is understood by himself".

This lays the groundwork for responsibility and self-control. Lave and Wenger argue, "activities, tasks, functions, and understandings do not exist in isolation; they are part of broader systems of relations in which they have meaning. These systems of relations arise out of and are reproduced and developed within social communities, which are in part systems of relations among persons" . For most early psychologists, this social development and growth of the self took place in wide varieties of face-to-face interaction and dialogue that has characterized human evolution from the earliest times. Now, however, face-to-face interaction is but one of many modes through which we see ourselves reflected in the response of others. Whether mediated interaction inevitably suffers due to social cues being filtered out or the media allows forms of hyper mediation that affords more effective means of social

interaction, is at present an unresolved issue. However, there can be no doubt that mediated interaction has come to form a major role in supporting cooperative work, collaborative understanding, discourse, and individual growth, as media use consumes an ever-greater proportion of our daily lives.

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Bandura (1977) wrote, “learning would be exceedingly laborious, not to mention hazardous, if people had to rely solely on the effects of their own actions to inform them what to do. Fortunately, most human behaviour is learned observationally through modelling: from observing others one forms an idea of how new behaviours are performed, and on later occasions this coded information serves as a guide for action”. Bandura further noted the necessity of opportunities for practice. This practice is best done in social contexts so that it can be refined through reaction and feedback from others. Humans learn socially in many ways, and one of the oldest of these is imitation. Aristotle argued, “To imitate is, even from childhood, part of man's nature (and man is different from the other animals in that he is extremely imitative and makes his first steps in learning through imitation)” .

Imitative learning has most often been studied among infants, but models of technical and cognitive apprenticeship also celebrate the effectiveness and efficiency of learning by imitation. However, learning by imitation has historically been limited by both time and space. Geographic separation can be overcome to a limited degree by video and immersion, but time restrictions also occur in place-bound and traditional forms of imitation. Asynchronous imitation occurs when one models the behaviour, consciously or unconsciously assesses the means of expression, the rationale, or the arguments of others as displayed in their asynchronous uttering. This modelling often occurs when responding to discussion or problem sets, to which the answers of others already serve as visible models.

Social learning looks to the authentic clues that arise from interaction with others in a specific context. In the everyday interactions of individuals, problems arise and through negotiation, acquisition of information, and reflection, these problems are resolved. Learning is not only the accumulation of facts and the understanding of concepts but also is both induced and confirmed through interaction and discussion with others. Even when one is alone, the shared use of language, cultural concepts, signs, and symbols both afford and constrain our understandings and creation of knowledge.

7. INFORMATION TECHNOLOGIES: CONCEPTS, TYPES AND FUNCTIONS

In the history of mankind, innovations in the field of technology have repeatedly had a revolutionary impact on social, political and economic development. In recent years, thanks to the rapid development of information technologies, the world community has moved to the formation of a new information space, which is created on the basis of computerization and network communications. These objective phenomena of modern reality are ac-companied by an increase in the amount of socially significant information used in the management systems of organized systems in order to rationalize their activities. Information accumulated in the process of human development becomes a source of saving time and public labor, that is, an essential factor in accelerating social development.

Today, the level of informatization of management processes isone of the most important indicators of social and economic progress achieved by states and individual societies and organizations. On the qualitative side, the increase in volumes of information used when solving management tasks leads to the rationalization of human labor and the growth of well-being. In addition, a modern person is surrounded by various information and information flows. Every year, the amount of information needed by a person increases. As a result, new methods and means necessary for its processing and preservation appear – more relevant and improved. Under the influence of these processes, a corresponding group is already beginning to form in society, for which the main professional occupation is working with information.

For any technology, a goal, object and means can be allocated. The goal of technology in production is to increase the quality of products, reduce the time of their production, and even reduce various types of costs. The production of information is aimed at the appropriate use of

information resources and their supply of all elements of the organizational structure and is implemented by creating an information system.

Information resources are the initial “raw material” for the management system of any organizational structure, and the final product is the adoption of certain management decision. Technology in general and information technology in particular is primarily a chain of procedure and

operations performed sequentially (parallel) in time. It is not just a complex of scientific and technical knowledge. This is a collection of rules regulating technological processes.

As for information technologies, this concept arose relatively recently – in the XX century. For the first time, the term «information technology» was used in 1958 by the authors of an article by H. Levitt and T. Whistler, which was published in the Harvard Business Review. The authors emphasized that this concept does not yet have a single established name and called it «information technology». Information technology, in their opinion, consists of several interconnected parts. One of them includes techniques for rapid processing of large volumes of information, and its embodiment is a high-speed computer. The second part focuses on the application of statistical and mathematical methods to decision-making problems. It is represented by mathematical programming and operations research. The third part consists of modeling higher-order thinking using appropriate computer programs.

Information technologies are a set of methods, production processes and software and technical means, united in a technological chain, the implementation of which ensures the collection, storage, processing, output and distribution of information. This is done with the aim of reducing the labor-intensiveness of the processes of using the information resource, increasing their reliability and efficiency. In view of the above, some researchers believe that information technology is a technology used to receive, store, transmit and/or analyze data. According to some scientists, information and communication technology is a broader term for information technology, which refers to all communication technologies that enable users to access, search, store, transfer and manipulate information in digital form. In addition, researcher N. Carr considers these terms identical, although he notes that the term «information technology» is widely used in the United States, while in other parts of the world the more accurate term «information and communication technology» is preferred. In particular, N. Carr notes that «information technology» is a vague term, and uses it as a designation of technologies used for processing, storing and transporting information in digital form.

If we take into account the definition of information technologies in the Ukrainian dictionary of legislative and standardized terminology, then information technology is understood as a technological complex consisting of software and technical means, methods and production processes. This

technological complex should make it possible to collect, create, store, process, accumulate and transfer information. So, information technology is a wide class of disciplines and fields of activity related to the technologies of data management and processing, including, with the use of computer technology.

Currently, information technologies are most often understood as computer technologies. Specifically, information technology deals with the use of computers and software to store, transform, protect process, transmit, and retrieve information. Specialists in computer engineering and programming are often called IT specialists. Such definitions are too simplified and do not fully give an idea of information technologies, do not fully reflect their essential features.

In our opinion, it is worth agreeing with some researchers that modern information technologies, represented by computers, network technologies and modern communication technologies are the dominant field of development of modern science and technology. Today's information technology is developing at a rate that no other technology has ever seen before, and has penetrated all aspects of society with a depth and breadth that no other technology has ever seen. It is worth agreeing that the main events of the 20th century, especially after the Second World War, no matter how short they were, did not ignore the enormous progress of information technologies and their great economic and social impact.

Information technology is a process that uses a set of means and methods of data collection, processing and transmission to obtain new quality information about the state of an object, process or phenomenon.

The goal of information technology is the production of information for human analysis and decision-making on the basis of any action. The introduction of a personal computer into the information sphere and the use of telecommunication means of communication defined a new stage in the development of information technology. New information technology is information technology with a «friendly» user interface that uses personal computers and telecommunications equipment.

The new information technology is based on such basic principles.

1) Interactive (dialog) mode of working with a computer.

2) Integration of actions with other software products.

3) Flexibility of the process of changing data and setting tasks5].

Common types of software products are used as information technology tools: word processors, publishing systems, spreadsheets, database management systems,

electronic calendars, functional information systems, etc. Information technology includes all the resources needed to manage information, including the computers, software, and networks needed to create, store, manage, transmit, and retrieve information.

Information technologies can be characterized by such basic properties as:

1) the subject (object) of processing (process) is data;

2) the purpose of the process is to obtain information;

3) software, hardware, and software-hardware computing complexes are the means of process implementation;

4) data processing processes are divided into operations according to the given subject area;

5) the choice of controlling influences on the processes should be carried out by persons who make decisions;

6) criteria for optimizing the process are timeliness of information delivery to the user, its reliability, reliability and completeness.

Like any technology, information technology must meet the following requirements:

– ensuring a high degree of separation of the information processing process into stages, operations, actions;

– inclusion of all necessary elements to achieve the set goal;

– information technology should have a regular character.

In order to evaluate and use information technologies in society, it is necessary to classify them.

The main types of information technologies include the following.

1) The information technology of data processing is intended for solving well-structured tasks, the algorithms for solving which are well known and for solving which all the necessary input data are available.

This technology is used at the level of executive activity of low-skilled personnel in order to automate some routine operations that are constantly repeated, managerial work.

2) Management information technology is intended for information service of all employees of enterprises related to the adoption of management decisions. Here, information is usually provided in the form of regular or special management reports and contains

information about the past, present and possible future of the enterprise.

3)The information technology of the automated office is designed to complement the existing communication system of the company's personnel. Office automation involves the organization and support of communication processes both within the company and with the external environment based on computer networks and other modern means of transmitting and working with information.

4) Information technology for decision-making support is intended for the development of a management decision that occurs as a result of a process in which a decision-making support system (a computing unit and a control object) and a person (a control unit that sets input data and evaluates the result) participate.

5) The information technology of expert systems is based on the use of artificial intelligence. Expert systems enable managers to receive expert advice on any problem that these systems have accumulated knowledge about.

It should be noted that information technologies are used in many areas of human activity, including in the management system. But even in one field, information technology can have several types and variants of use. The following types of information technologies are distinguished in the management system:

– communication systems;
– document fl ow automation systems;
– accounting automation systems;
– decision-making systems;
– systems for automating banking operations;
– systems of automated workplaces.

In addition, regardless of the type of information technology, they all perform a number of functions. The main functions of modern information personnel in order to automate some routine operations that are constantly repeated, managerial work.

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– accounting automation systems;

– decision-making systems;

–systems for automating banking operations;

– systems of automated work places. In addition, regardless of the type of information technology, they all perform a number of functions. The main functions of modern information technologies include: collection, search, processing, and storage of data, which in a certain way influence management, production of new information and management optimization problems.

An important stage is not only the automation of time-consuming routine and regularly repeated operations for processing a large amount of data. Equally important is the processing of data in order to obtain fundamentally new information that will contribute to the adoption of effective management decisions. It is also worth agreeing with some researchers who believe that the main functions of information technology – storage, processing and transportation of data – have become available and

affordable to everyone. Information technologies began to transform from potentially strategic resources into raw factors of production.

An information system is a system designed for receiving, storing, processing and issuing information, that is, a system whose main subject and product of functioning is information.

Information systems are more than just computers. Information systems create value for enterprises and provide organizational and management solutions for responding to environmental challenges. An information system is defined from a technical point of view as a system consisting of a number of interconnected components that collects processes, stores and issues information to support organizational decision-making and management control.

An automated information system is a set of hardware and software or a specific purpose, functioning on the basis of computers, which have passed tests with fixed quality indicators and are provided with a set of documentation sufficient for qualified operation for the intended purpose and use as products of industrial and technical purpose.

In the context of the management process, the following main functions of information systems are distinguished:

– computational – timely and high-quality execution of information processing in all aspects of interest to the management system;

– communication – ensuring prompt transfer of information to specified points;

– information – provision of quick access, search and issuance of necessary information of all kinds;

– memorizing – continuous accumulation, systematization, storage and updating of all necessary information;

– observational – tracking and formation of all external and internal information necessary for management;

– regulatory – the implementation of informational and management in fluences on the object of control when the parameters of its functioning deviate from the specified (planned) values;

– optimization – provision of optimal planned calculations and recalculations as goals, criteria and conditions of operation of the facility change;

– self-improvement – accumulation and analysis of experience for the purpose of reasoned selection of the best management methods;

– diagnostic – diagnostics of the state of the control object;

– predictive – identifying the main trends, regularities and indicators of the development of the object and the environment.

An information system can include various subsystems, the composition and interaction of which allows for the implementation of its functions. The following types of subsystems are distinguished: functional, supply and organization.

Functional subsystems of the information system implement and support models, methods and algorithms for obtaining information.

Support subsystems include the following components:

– information support – is a set of implemented solutions in terms of volumes, placement and forms of organization of information circulating in the management system;

– technical support – a complex of technical means involved in the technological process of information transformation in the system;

– software – includes a set of programs of regular use, necessary for solving functional tasks, and programs that allow the most effective use of computing equipment;

– mathematical support – a set of mathematical methods, models and information processing algorithms used in the system;

– linguistic support is a set of language tools used in the system to improve the quality of its development and facilitate human-machine communication.

Organizational subsystems include:

– human resources – the composition of specialists participating in the creation and operation of the system, staff list and functional duties;

– ergonomic support – a set of methods and tools used in the development and functioning of IP, which create optimal conditions for the activities of personnel and the fastest possible mastery of the system;

– legal provision – a set of legal norms regulating the creation and functioning of information technologies, as well as the procedure for obtaining, transforming and using information;

– organizational support – a set of solutions that regulate the processes of creation and functioning of the system as a whole, and its personnel.

In most cases, all the types of information subsystems listed above are used simultaneously and sometimes integrated with each other.

Data from one subsystem can be transferred and processed in another subsystem. Considering the above, we can say that the main purpose of the information system is the implementation of information technology (organization of storage, processing, transmission of information, etc.). The concepts of «information technology» and «information system» are closely related, but at the same time have significant differences. The functioning of the information system is impossible without knowledge of information technology oriented towards it. Information technology can exist outside the environment of the information system, but high

efficiency of information technology is achieved only in information systems developed taking into account the specifics of the relevant technological operations. In addition, information technologies and systems are primarily management tools. Like any others, they serve to coordinate and control the progress of all processes during the achievement of established goals. The simple possession of these tools, like any other, does not guarantee success, but their absence can lead to losses and risks.

In addition, like any technology, information technologies have advantages and disadvantages. The advantages of information technologies are clear to each of us. On the downside, information technology can lead to job losses in traditional industries such as manufacturing and services. They can lead to social problems such as unemployment and lower living standards. In addition, excessive use of information technology can lead to poor health, including problems with vision, posture and mental health.

It is worth emphasizing that information technologies are and will be both a boon and a threat to the modern world. In order to minimize the negative impact, it is necessary to implement technologies taking into account environmental and social aspects, as well as to educate people about the responsible use of information technologies. Only then will information technologies become a boon for the modern world, and not a threat.

Modern society has moved to a new life stage, where information plays the main role. As a result, the modern development of society is directly interconnected with the need to collect process and transmit large volumes of information and transform it into a product of significant value. This was the reason for the global transition from an industrial to an information society. And the emergence and spread of the Internet led to a large-scale growth of communication in various spheres of human activity.

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We have emphasized that modern information technologies require the ability to competently work with information and information systems. In addition, the implementation of the specified works requires orientation in the types of information technologies. A detailed understanding of the functions performed by one or another type of information technology will not be

superfluous. The above will only help in working with information technology, which does not require complex preparation large costs and complex equipment.

It has been established that information technologies occupy an important place in the life of a modern person.. Today, there are practically no areas in which information technologies are not used. In particular, the active development of information technologies and their implementation increased the speed of information exchange. This made it possible to carry out complex calculations in a very short time. In addition, information technologies have become one of the modern methods of communication, the main advantages of which are universal accessibility. The development of information technologies made it possible to obtain any necessary information in a short period of time.

The resulting hybrid marked a revolutionary leap in the history of information technologies. Today, production and transport, banks and exchanges, mass media and publishing houses, defense systems, social and law enforcement databases, service and health care, educational process-es, offices for processing scientific and business information, finally, the Internet – information technologies are everywhere.

Today, it is practically impossible to find a field in which information technologies are not used. Therefore, we can claim that information technologies have deeply penetrated our lives and modern society, and are changing them in a fundamental way. Humanity will never be the same as it was before the advent of information technology. And it is also practically impossible to predict the possible ways of further development of information technologies. Only one thing is clear – humanity is waiting for something grandiose. And if the pace of development of information technologies does not change, it will happen soon enough.

8. INFORMATION AND COMMUNICATION TECHNOLOGY (ICT)

Information and communications technologies (ICTs) are part of the modern infrastructure of organizing and producing services and interactions. They are generally referred to as a collection of devices, networking tools, software applications and operating systems that allow individual or corporate users to collect, access, store, transmit, analyze, compute and share data and information. Cutting-edge ICT such as high-speed internet, mobile technology, machine learning and artificial intelligence (AI), robotics, internet of things (IOT) and blockchain have transformed everyday human interactions in an unprecedented manner.

The spread of ICT has given rise to the 'digital economy', defined as 'that part of economic output derived solely or primarily from digital technologies with a business model based on digital goods or services'. In 2016, the digital economy worldwide was worth US$11.5 trillion, or 15.5 per cent of global gross domestic product (GDP). By 2025, it is expected that the digital economy will reach 24.3 per cent of the global economy (Huawei and Oxford Economics 2017).

It is widely acknowledged, however, that many trends associated with the growth of the digital economy also pose major socio-economic challenges, such as rising inequality and the proliferation of non-standard work contracts in the 'gig economy' enabled by online platforms

. The production and use of ICT also has a large and growing environmental footprint. In 2018, the sector used an estimated 3.6 per cent of global electricity and caused 1.4 per cent of global carbon emissions, while extracting large amounts of minerals and natural resources.

The social and solidarity economy (SSE) overlaps with the ICT sector through its production and service delivery. SSE organizations and enterprises (SSEOEs) are also affected by emerging business models that are anchored in ICT and the corresponding so-called Fourth Industrial Revolution, where the role of technologies and autonomous intelligence is expected to further impact upon human cognition and emotions. ICT enables SSEOEs to scale up and to re-image new modalities of organizing collaboration, and may also affect the manifestation of the SSE principles of solidarity, fair benefit sharing and democratic decision-making.

8.1. The Role Of SSEOEs In Developing And Producing

SSE principles and values have been applied to the development and production of ICT since the 1980s; a decade that was characterized by important breakthroughs which set the path for the widespread adoption of digital information and communication technology. Whereas SSEOEs play a relatively significant role in the development of software and provision of ICT services, hardware production is mostly dominated by for-profit private sector businesses. It may be due to the high entry barrier of capital requirement which SSEOEs have more difficulty in meeting. The following three subsections describe these trends.

8.2. From Free Software To The Digital Commons

A large part of software was developed in universities and corporate research centers in the

1960s and early 1970s. In these places, an academic culture of knowledge sharing was prevalent, and developers with research funding did not face the immediate pressure for cost recovery or return on investment. As commercial distribution of proprietary software increasingly came to dominate the software industry, ideals of sharing and collaboration also became less prevalent and intellectual property rights became more vigorously defended.

In 1983, Richard Stallman founded the free software movement which later became institutionalized as the Free Software Foundation (FSF). The declared mission of this non-profit organization is to ‘promote user freedom’ and to ‘defend the rights of all software users’ by advocating for and developing ‘free software’ (Free Software Foundation 2019). FSF formulated a set of ‘four essential freedoms’ which software developers must grant to users before being qualified as ‘free’ (not necessarily being free of charge):

1. The freedom to run a program as a user wishes, for any purpose;
2. The freedom to study how the program works and change it so it does the computing as the user wishes …
3. The freedom to redistribute copies so the user can help others;

4. The freedom to distribute copies of the modified versions to others [and to] give the whole

community a chance to benefit from one's changes. (Free Software Foundation 2021. Putting users and their interests first, together with a broader social objective beyond its own operational reach, reveals a resemblance with the principles and values of SSE.

Also the main sponsor of the GNU project, which maintains a free operating system (GNU/Linux) and an extensive collection of free software packages. Another important aspect of free software is that 'free' does not prohibit commercial use or paid professional support, which the Foundation considers fundamental to achieve its aims (Free Software Foundation 2019).

The free software movement can therefore be counted as an innovative interpretation of SSE

principles in ICT development. GNU/Linux (General Public License) marked the beginning of a widening community of developers who were convinced of the benefits of sharing source codes to enable collaborative improvement. But not all of them may have been just as convinced of the 'ethical imperative' to maintain and defend users' freedom against the growing dominance of proprietary software, as promulgated by free software advocates.

In 1998, some of them became engaged in creating the Open Source Initiative (OSI) and open source label. Its founders were mainly convinced by the practical benefits of sharing source codes and improving them by engaging the developer community. Instead of insisting on a commitment to the idea that all developers should uphold users' freedoms, like the FSF, the OSI founders also cherished the 'pragmatic, business-case' approach for writing open source software, and decided to create a label and position it in clear distinction to the 'philosophically- and politically-focused' free software label and movement (Open Source Initiative 2021).

Besides these ideological and strategic differences, however, the OSI's definition of open source does not contradict the four freedoms per se. Stallman (2009, 31) himself acknowledges that 'nearly all open source software is free software', although they 'stand for views based on fundamentally different values'. Similarly, FSF's free software licence GNU is listed as one of the most popular open source licences on the OSI's website, together with others that comply with the open source definition (Open Source Initiative 2021). Both open source and free software are also often associated

with the ‘copy left’ concept and movement, which further encompasses licences that apply the conditions to other works, including writing, photography, art and scientific discoveries. Notable examples include the Mozilla Public Licence, and the Creative Commons licence.

Similar to FSF’s and OSI’s approach, the Creative Commons licence is based on the idea

of collaboration as a source of creativity and innovation, and therefore waives a limited set of rights to any recipient or creator who wants to use the protected content for private or other creative purposes, provided that authors be attributed, and the resulting work will also enter the ‘creative commons’. Creative Commons has become the most widely applied licence in the realm of ICT-based content and services. The most notable platforms using the licence are Wikipedia and the online photo sharing service Flickr.

The use of the notion of ‘commons’ emphasizes the nature of information and other content covered by the licence as a type of common-pool resource accessible to all members of society (see entry 13, ‘The Commons’). A similar extension of the information and knowledge was later formulated by Hess and Ostrom (2006), observing the similarities between natural commons and ‘social commons’ which are established and maintained through the voluntary contributions of individuals and groups.

Yochai Benkler of Harvard University employs the term prominently to ‘commons-based peer production’ as a ‘socio-economic system of production that is emerging in the digitally networked environment’. In 2010, Mayo Fuster Morell further applied the concept to online creation communities as a form of collective action to create and govern the ‘digital commons’. By extending the option of collective action from the natural commons, these authors suggest that governance arrangements can be found that may outperform market or hierarchies in managing software and other (ICT-based) content. While a general discussion on the overlap of the commons and SSE is provided elsewhere in this Encyclopedia (see entry 13, ‘The Commons’), some writings explicitly suggest to make the connection between open source, digital commons and other related movements on the one hand, and SSE principles and values on the other. For instance, it is suggested that maintaining democratic principles in such communities is both possible and desirable. Development and application of a framework to assess the democratic quality of online platforms in general is also taking place, highlightingthe role of platform cooperatives and other forms of SSE units creating and using digital content. Platform ‘commoning’ has also been

described as a new way to build and support SSE using commons-based pool production.

8.3. SSEOEs Providing ICT Services

SSEOEs and their practices can also be found in the ICT service sector which encompasses

activities such as creation and maintenance of information technology (IT) infrastructure (websites, databanks, and so on) and similar services. Examples of SSE providers of ICT services operate while observing SSE principles such as democratic self-management of workers or users, and often demonstrate a commitment to values associated with cooperation and openness which may also be expressed through the use and active promotion of open source or free software in their work. Two organisations that provide ICT-related services and are organised along SSE principles, Koumbit and Enspiral, will be briefly profiled here to illustrate the spectrum of actors.

Koumbit is a member-based not-for-profit organization based in Montreal whose primary activity is providing web services, including designing, developing and hosting websites. The individuals and organizations who become members of Koumbit must subscribe to a set of values which centre on non-hierarchical self-management by the workers, a commitment to open formats and free software, and solidarity. Around 20 worker-members belong to the Conseil de Travail (Council of Workers), where important decisions are made.

In addition, issues that affect only some workers are dealt with in committees or teams, as is the case in many cooperatives.

Enspiral, in contrast, is a more community-oriented cooperative organized around the principles of cooperatives and SSE networks. Enspiral is attempting systemic changes at a meta-level by facilitating an ‘ecosystem of purpose’. The organisation consists of full- and part-time members who work on joint projects but can also work on projects separate from Enspiral. The Enspiral Network was founded in 2010 in Wellington, New Zealand, as a collective of individuals doing contract work together, excited by the possibility of creating something more. The Enspiral Network now includes over 28 members and 124 contributors working on IT consulting projects for government, business or community organizations. Among the different modes by which people interact at Enspiral are ‘stewards’, or support pairs,

and ‘pods’, which are any small group of people meeting in person or virtually generally around a common goal or discussion theme. Most of the internal work takes place through formal and informal working groups. Enspiral members share work (projects) and cherish ongoing learning opportunities (retreats).

8.4. Challenging Market Entry For SSEOEs Producing ICT Hardware

As for the industry sector overall, the SSEOEs occupy only a marginal presence in the production of ICT hardware, mainly comprising components for telecommunications infrastructure, as well as computers, (smart)phones, servers and other devices. In 2019, for instance, out of the 300 largest cooperatives by turnover in US dollars, only three were active in the industry sector (four if turnover is divided by GDP per capita) (EURICSE and ICA 2021).

Several characteristics of the production for industrial goods, including ICT hardware, make it relatively difficult for SSEOEs to enter these markets. Particularly, the high capital intensity of machinery required for serial production of high-technology components poses an issue for entities which depend greatly on member contributions and revenue. As ‘employment-oriented’ organizations they further put particular emphasis on the value and rights of workers, and often face difficulties in attracting financial capital due to their democratic governance structure and limited profit distribution.

However, there are a few examples of SSEOEs that participate in the industrial production of ICT hardware. One of these exceptions is the Basque worker cooperative federation ondragon Corporation. With more than 81 000 employees and a global turnover of US$13.7 billion in 2019, it is by far the largest SSE organization in the industry and utilities sector, and the 37th largest cooperative in the world. Established in 1956 as a manufacturer of paraffin heaters, it has evolved into a multinational SSE organization active in banking, insurance, a wide variety of industry goods and services, retail (including supermarkets, petrol stations, travel agencies, and more), as well as knowledge-related activities combining education, training and innovation. From the universe of worker cooperatives that are part of Mondragon, two organizations stand out as producers of ITC-based goods and services.

Mondragon Sistemas (MSI Grupo) is a group of SSE organizations specialized in the digitalization of production processes. Another SSE organization, Mondragon Telecommunications, provided telecommunication engineering services, but was dissolved in 2016.

Another company that embraces SSE principles and values in the production of ICT ardware industry is Fairphone, founded in the Netherlands. Launched in 2010 as an wareness raising campaign about conflict materials such as cobalt, which are essential ingredients for smartphone components, the founders registered as a company in 2013 with a commitment to contribute to a 'fairer electronics industry' enshrined in the by-laws. Fairphone produces smartphones with extended longevity by making all components replaceable and easy to repair for standard users, continued software updates and long-term support. These product design features and related business practices are in stark contrast to other phone manufacturers or brands that prioritize profit over users' interests and the environment, by stimulating unsustainable consumption, short product life span and waste.

These brands require users to buy a whole new phone when only parts (such as the battery or display) need to be replaced, or make it so difficult to repair that it becomes an expensive expert's job. Fairphone also demonstrates the 'SSE difference' through its organizational culture and participation of its workforce and stakeholders in decision-making, which are institutionalized in an elected governing body, a Workers Council, and ongoing communication on pay and satisfaction with in-house as well as supplier employees.

Education plays an important role in improving the welfare of society. According to Rousseau the main purpose of education is to give humans the ability to live in society. This ability is in the form of knowledge or skills and behavior that is accepted by society [1]. A person's ability will be able to develop optimally if he gets a good and appropriate learning experience. The educational process is an activity of mobilizing all components of education by educators that are directed at achieving educational goals. How the educational process is carried out greatly determines the quality of the results of achieving educational goals. The quality of the educational process can be determined from two aspects, namely the quality of the components and the quality of their management.

The two aspects are mutually dependent on each other. Even though the education components are adequate, if the management is not

appropriate, it will result in suboptimal results. Therefore, components and management in an educational institution must go hand in hand and take place in a balanced manner.

One of the components needed in the world of education is the existence of effective and efficient information technology (IT). Why is that? Because the world of education today has openly competed to produce new discoveries and knowledge related to technology. Information technology (IT) has made many contributions to the world of education, in this case the education sector has had a considerable impact with advances in information technology (IT). Basically Education is a process of communication and information from educators to students which contains educational information. The elements contained in it are educators as sources of information, media as a means of presenting ideas, ideas and educational material and students as recipients of information. Some of these elements get a touch from information technology media.

In the world of education, the role of information technology (IT) is used as an absolute value that must be mastered to welcome the era of globalization with rapid technological progress competition. In the past, one had to wander or walk to meet experts to discuss a problem. Currently, this can be done from home by using a communication device such as a telephone or by sending an email. Even at this time assignments at the elementary school level to tertiary institutions also use technology, for example making articles by searching for news or literature on the internet and typing them using a computer (laptop).

9. INTERNET TECHNOLOGIES

Computer networks made it possible not only to use common network resources, but also to exchange information in real time, which ultimately led to the creation of the Internet.

Computers connected to the Internet, or global network, can be divided into two groups: servers and clients. Servers and clients are interconnected in the network.

A server is a common resource that provides common services to computers connected to the network and serves to use resources on the network.

The term server is often used in relation to a computer, but at the same time it can also be used for a program running on a computer. Many servers are designed to perform only one, specific task.

For example: an e-mail server uses a program that serves only e-mail-related tasks; a web server (network server) uses a program that serves only network-related tasks.

Clients are individual computers that connect to a server. Computers located at home and often in offices do not serve other computers and therefore can be called clients.

Client computers run individual computer programs that perform various tasks. For example: an email program (Microsoft Outlook), an Internet browser (Internet Explorer) are client programs.

A personal computer, which is a client, runs a web browser (e.g., Internet Explorer) and is a client program.

When a user on this computer searches for information on the Internet, the web browser connects to a remote server and requests the corresponding web page. The server computer program is launched on the remote server and, after retrieving the requested information, the requested web page appears on the client's screen.

In 1991, when Tim Berners-Lee invented the World Wide Web. It was a system of Internet servers that served specially formatted documents.

These specially formatted documents are text documents created in HTML (Hypertext Markup Language) - a special formatting computer language. The web browser interprets this text document in such a way that web pages are created.

Web pages contain Formatted texts, graphics, animations, audio and video files that you point to with a mouse click while navigating (moving) on the network. In order to connect to the Internet, a personal computer must be equipped with a modem and a browser.

A modem is a device that can convert data output from a computer into a format that can then

be transmitted over connection lines. It also converts incoming data in such a way that the computer can perceive it. A modem can be located in a personal computer - an internal modem,

external modems are also used.

A web browser is a piece of computer software that allows you to navigate the World Wide Web. For example: Internet Explorer, Mozilla Firefox, Safari, Netscape, Opera. Avant.

Internet providers: In order to To connect to the Internet, in addition to equipping your personal computer with a modem and a web browser, you need an Internet service provider (ISP). Internet service providers are companies that provide connections to the Internet. For a certain subscription fee and an initial connection fee, you can purchase a special software package from an Internet service provider. This package defines the conditions for connecting to the Internet (connection time limit, Internet speed, etc.).

The TCP/IP protocol suite provides fast and reliable transmission of information. To do this, the message to be sent is divided into small individual packets, numbered, equipped with a special address and sent.

Application protocols (higher-level protocols) are responsible for providing special services. For example, the http protocol is responsible for the transfer of hypertext web pages, the ftp protocol is responsible for the transfer of programs and data files, and the SMTP and POP protocols are responsible for the transfer of electronic mail. Each protocol operates according to its own rules and provides conditions for the higher-level protocol.

9.1. Internet Addressing System

Each host computer connected to the Internet is assigned a unique IP address. This address uniquely identifies the computer's location on the Internet. An IP address consists of four numbers separated by dots. The value of each number ranges from 0 to 255. For example: 129.42.17.90 It is quite difficult and inconvenient for users to remember addresses written in numbers.

Therefore, in order to simplify the work, a Domain Name System (DNS) was created, according to which each IP address corresponds to a unique text name. For example: www.itvet.ge; www.microsoft.com.

To connect to a key computer, we can use both a numeric and a text address. Domain name service is provided on the Internet by special DNS servers. Each web page has its own address on the Internet, which is denoted by the English abbreviation URL, which stands for Resource Locator, the Uniform Resource Locator is an abbreviation for a unified resource. The first part of the address http:// - HTTP (Hypertext Transfer Protocol) is used to exchange information, which determines how a document is formatted and how it is transmitted over the Internet. To place information on the Internet, usually one page is not enough. Therefore, several interconnected web pages are created - Web Pages, the set of which is called a Web Site. Sites are located on servers. And to view them, the user uses the site address. The site address begins with the abbreviation www (word wild web), which indicates that the Internet node is included in the Web network. (Occasionally, nodes included in the Web network may have a different prefix). Then comes the name of the institution, organization.

9.2. Email

Email has been around for more than three decades. Since the 1990s, it has become widely known to the general public and has grown exponentially. Other forms of network communication, such as instant messaging and voice over IP calls, have expanded significantly over the past decade, but email remains the workhorse of Internet communication. It is widely used in industry for internal company communication.

Email protocols have also evolved over the period of their use. The first email systems consisted simply of file transfer protocols, with the convention that the first line of each message (i.e. file) contains the recipient's address. Over time, email has been added to many features, such as the ability to send a single message to a list of recipients. Multimedia capabilities became important in the 1990s, with the ability to send messages with images and other non-textual content. Email readers also became much more sophisticated, moving from text-based to graphical user interfaces.

9.3. Architecture And Services

The architecture of an electronic mail system is shown in Figure 8.1. It consists of two types of subsystems: user agents, which enable users to read and send e-mail, and message transfer agents, which transport messages from source to destination. We also refer to message transfer agents informally as mail servers.

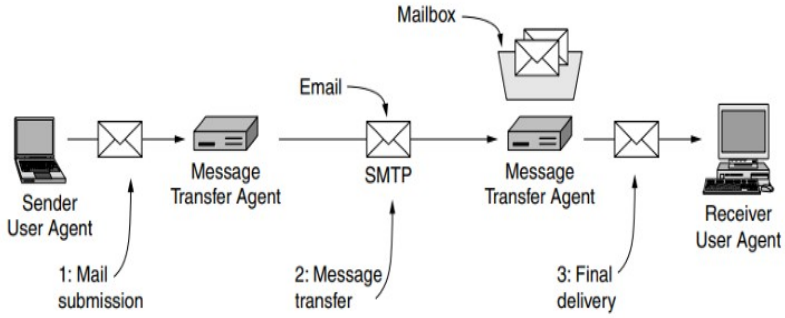


Figure 8.1. Architecture of an Electronic Mail System

A user agent is a program that provides a graphical interface, or sometimes a text and command-based interface, that allows users to interact with the e-mail system.

Some user agent processing can be done automatically, based on what the user wants. For example, incoming mail can be filtered to remove messages that are likely to be spam. Some user agents include advanced features such as setting up automatic email replies. The user agent runs on the same computer that the user reads their mail from. It is simply another program and may only be run at certain times.

Message transfer agents are usually system processes. They run in the background on the mail server machines and are designed to be always available. Their job is to automatically transfer

email from the system to the recipient via SMTP (Simple Mail Transfer Protocol). This is the message transfer step.

SMTP sends messages over connections and reports delivery status and any errors. There are many applications where delivery confirmation is important and may even have legal

importance.

Mailboxes store e-mail messages received by users. They are stored by mail servers. User agents simply present users with a view of the contents of their mailboxes. To do this, user agents send commands to the mail server to manipulate the mailboxes, for inspection purposes.

Mail is sent between message transfer agents in a standard format. The main idea behind message formats is the distinction between a mail folder and its contents. A folder represents a message. It contains all the information needed to deliver a message, such as the destination address, priority, and security level, all of which are different from the message itself.

An internal message consists of two distinct parts: the header and the body. The header contains control information for user agents. The body is intended solely for the recipient.

9.3.1. User Agent

A user agent is a program (sometimes called an email reader) that accepts various commands to compose, receive, and reply to messages, as well as to manipulate mailboxes. There are many popular user agents, including Google Gmail, Microsoft Outlook, Mozilla Thunderbird, and Apple Mail. They can vary greatly in their appearance. Most user agents have a menu or graphical interface that requires a mouse or a touch interface. After reading a message, the user can dispose of the message. Options include deleting the message, sending a reply, and saving the message for later reference. Most user agents can manage a single mailbox for incoming mail and several folders for stored mail. Folders allow the user to organize messages by sender, subject, or other category. For example, the command fields and content of messages are often checked, along with user feedback on previous messages, to determine whether a message is spam. Many ISPs and companies produce software that labels mail as important or spam so that the user agent can move it to the appropriate mailbox. ISPs and companies have the advantage of seeing mail for many users and may have lists of known spammers. If hundreds of users receive a similar message at the same time, it is probably spam. The most popular spam is generated by compromised computers, called botnets.

Explicit constructs such as folders, user agents now provide rich search capabilities within the mailbox. Search capabilities allow users to quickly find messages.

Another useful feature is the ability to respond to messages in some way automatically. One response is to forward incoming email to another address, such as a computer operated by a commercial paging service that sends mail to the user using a satellite and displays the Subject: line on its pager. These automatic responses must run on the mail server, since the user agent may not be running all the time and may only occasionally check for e-mail.

Mail composition involves composing messages and replies to messages and sending these messages to the rest of the mail system. While any text editor can be used to compose the body of a message, editors are typically integrated with the user agent so that it can assist with addressing. Other features include adding a signature block to the bottom of the message, spell checking, and calculating digital signatures that show that the message is valid.

Messages sent to the mail system have a standard format that must be constructed based on the information provided to the user agent. One expected form of address is user@dns-address. However, it is worth noting that other forms of address exist. In particular, X.400 addresses look radically different from DNS addresses. X.400 is an ISO standard for message processing systems.

9.3.2. Message Formats

Messages sent by a user agent must be placed in a standard format that is processed by message transfer agents. Basic ASCII email uses RFC 5322, which is the latest version of the

original Internet Message Format as described in RFC 822.

9.3.2.1. RFC 5322 - Internet Message Format

Messages consist of a primitive envelope (described as part of SMTP in RFC 5321) followed by a number of header fields, a blank line, and then the message body. Each header field (logically) consists of a single line of ASCII text containing the field name, a colon, and for most fields, a value.

The Reply-to: field is sometimes used when neither the originator of the message nor the sender of the message wants to see the reply.

Message-Id:

is an automatically generated number that is used to link messages together (e.g., when used in the In-Reply-To: field) and to prevent duplicate delivery.

RFC 5322 explicitly states that users are allowed to specify additional headers for their own personal use.

By convention from RFC 822, these headers begin with the string X. It is guaranteed that no future headers will use names that begin with X to avoid conflicts between official and private headers. The headers are followed by the user's message body.

9.3.3. Message Transfer

Mail transfer by message transfer agents is done using the SMTP (Simple Mail Transfer Protocol) protocol.

The simplest way to transfer messages is to establish a transport connection from the source machine to the destination machine and then simply transfer the message. The first use of SMTP is to send mail, the first step in the architecture of email. This is the means by which user agents send messages to the mail system for delivery. The second use is to transfer messages between agents (step 2).

Email is delivered from the sending computer to port 25 on the receiving computer. This port is listened to by the mail server.

This server accepts incoming connections, performs security checks, and receives messages for delivery. If the message cannot be delivered, an error message containing the first part of the message that was not delivered is returned to the sender.

SMTP is a simple ASCII protocol. The use of ASCII text makes it easier to design, test, and debug protocols. They can be tested by issuing commands manually, and the message logs are easy to read.

If the server wants to receive an email, the client declares who it is from and to whom it is addressed. If such a receiver exists at the destination, the server grants the client permission to send the message. The client then sends the message and the server acknowledges it. No checking is required, since TCP provides a reliable byte stream.

Finally, while the syntax of the four-digit commands from the client is strictly specified, the syntax of the responses is less strict. Only the numeric code really counts. Each implementation

can put whatever string it wants after the code.

9.4. Webmail

An increasingly popular alternative to IMAP and SMTP for providing email service is to use the Internet as an interface for sending and receiving mail. Widely used webmail systems include Google Gmail, Microsoft Hotmail, and Yahoo!. Webmail is an example of software (in this case, a mail user agent).

In this architecture, the provider typically runs mail servers to receive messages for users on SMTP port 25. However, the user agent is different. It is a user interface that is provided through web pages. This means that users can use any browser they like to access their mail and send new messages.

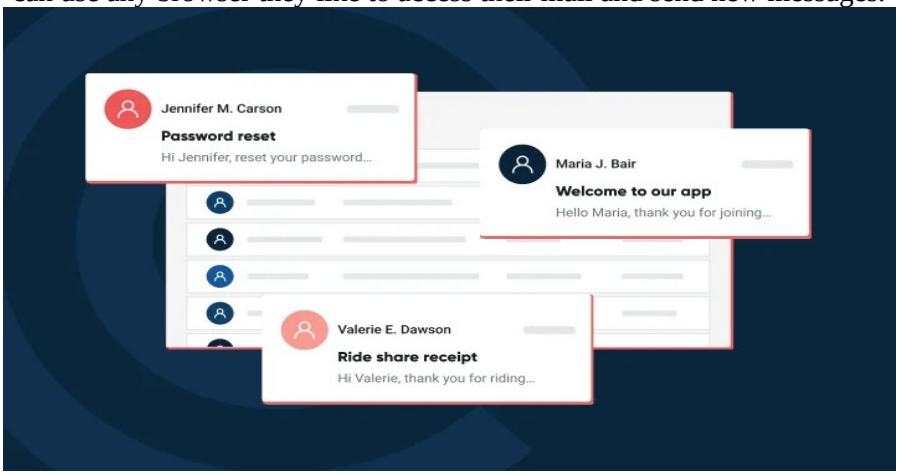


Figure 8.2. SMTP Port.

When a user logs into the provider's email web page, a form appears asking the user for a login name and password.

A login name and password are sent to the server, which then validates them. If the login is successful, the server finds the user's mailbox and builds a list of web pages with the contents of the mailbox.

To provide a responsive interface, web pages often include JavaScript programs. These programs run locally on the client in response to local events (e.g., mouse clicks) and can also download and upload messages to prepare the next message.

In this model, mail is sent using standard web protocols by placing data in the URL. The web server takes care of inserting the messages into the traditional mail delivery system.

Standard web protocols can also be used for security. These protocols are concerned with encrypting web pages, not sending the content of a web page through email.

9.5. Future Trends In Computer Networking

Computer networking technology continues to evolve and promises transformative trends in the future that will change connectivity, communication, and information exchange. The integration of 5G technology will revolutionize network speed and responsiveness, enabling a more connected and efficient digital ecosystem. The use of decentralized processing power closer to end users will enhance real-time data processing and reduce latency.

The rise of software-defined networking (SDN) and network function virtualization (NFV) means a transition to a more flexible, scalable, and programmable network infrastructure.

Artificial intelligence (AI) and machine learning (ML) will be crucial for optimizing network management, automating security protocols, and predicting potential problems. Moreover, the Internet of Things (IoT) continues to grow and will expand the scope of the network to include many interconnected devices. Quantum computing has implications for network security The potential for revolution, through advanced encryption methods.

Collectively, these trends point to a future where networks are faster, smarter, and seamlessly integrated into every aspect of our digital lives. We look at the most important areas and trends for the future.

Artificial Intelligence (AI) Continues to Expand 01 05 The capabilities of computer systems like Deep Blue helped legitimize artificial intelligence (AI) decades ago. Since then, both the processing speed of computers and their ability to operate have developed tremendously.

One of the main barriers to AI has been its limited ability to communicate and interact with the outside world. With the much faster wireless speeds available today, it is possible to add sensors and network interfaces to artificial intelligence (AI) systems, opening up the possibility for the development of new applications.



Fig. 8.3. IP3

9.6. Internet Of Things (IoT) Gadgets

The Internet of Things (IoT) is a network operating system, including for improving processing speed.

With Wi-Fi or Bluetooth support in lighting systems and the quality of lamps, expect further improvements in terms of programming options and ease of integration. 5G will dramatically increase the speed of mobile connections.

Researchers continue to test prototype versions that could become part of standard 5G networks. While reports from these tests indicate maximum data speeds of multiple gigabytes per second (Gbps), users should also be interested in the improved coverage of 5G signals.

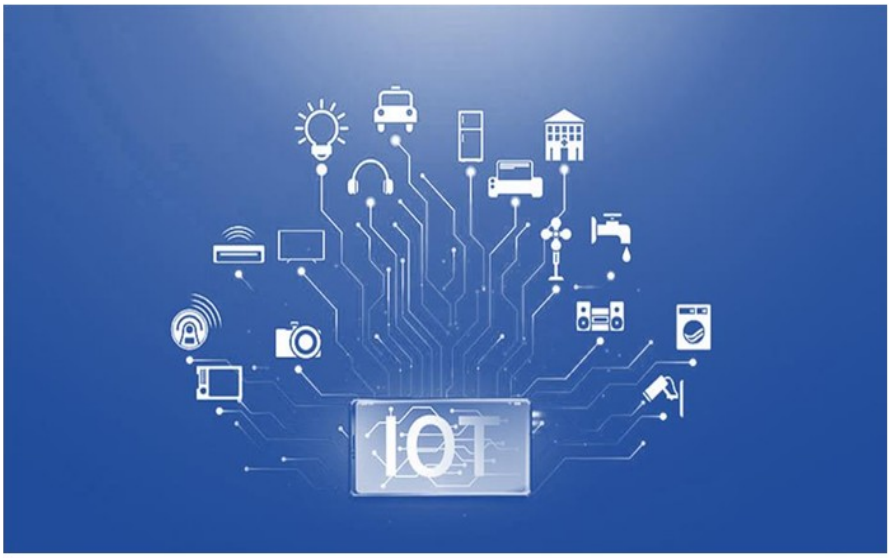


Fig. 8.4. IoT gadgets

9.7. IPv6 Deployment Accelerates

Internet Protocol version 6 (IPv6) will one day replace the traditional Internet Protocol addressing system, IPv4. The Google IPv6.

Adoption page shows how quickly IPv6 is being adopted. As we know, the pace of IPv6 deployment has continued to accelerate since 2013, but it will take many more years to completely

replace IPv4. IPv6 will bring significant benefits to businesses, both directly and indirectly. With the expanded amount of available IP address space, by accommodating an almost unlimited number of devices, ISPs will be able to easily manage their customer accounts.

IPv6 also adds other enhancements that increase the efficiency and security of TCP/IP traffic management on the Internet.

9.8. SD-WAN Development – Software-Defined Wide Area Network

(SD-WAN) is a technology that offers companies more flexibility than previous WAN systems. While traditional WANs allow businesses with multiple locations to provide employees with access to data, files, and

applications over Multi-Protocol Label Switching (MPLS), SD-WAN takes this process one step further, with Long Term Evolution (LTE).

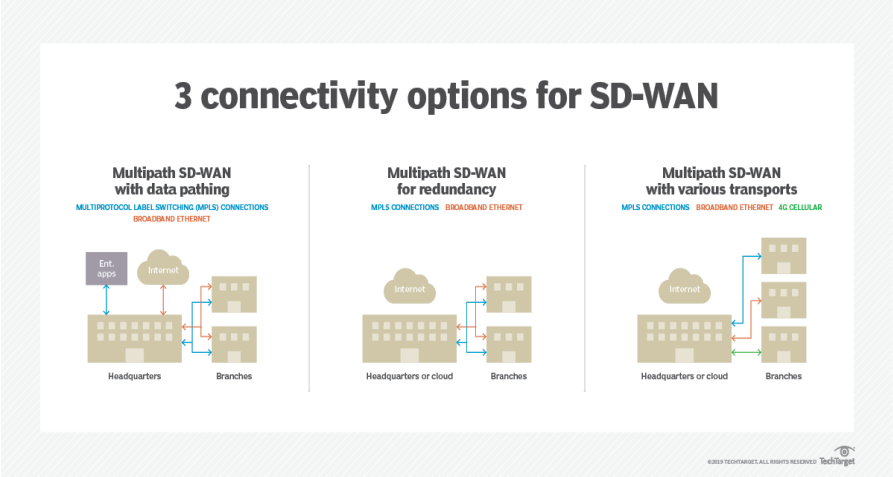


Fig. 8.4. SD-WAN

SD-WAN adds cloud-based applications, allowing employees to remotely access enterprise

applications such as Salesforce, Amazon Web Services, and Microsoft 365.

SD-WAN software applications offer several key benefits:

User Interface: The core technology of SD-WAN connects remote websites to networks more easily, with better throughput and more reliable connectivity.

Simplicity: SD-WAN uses automation and other benefits to simplify the process of connecting networks in mixed environments (including on-premises, hybrid, and cloud).

Multi-cloud readiness: Today, more than 90% of enterprises are investing in a multi-cloud strategy, and the right SD-WAN software application can easily manage this environment.

The technology is still relatively new, so customers and providers are experimenting to understand how to use this innovation to increase productivity, improve business agility, and improve security.

Within a few years, SD-WAN is likely to become the new norm in practice.

9.9. SD-WAN Challenges

While the advantages of SD-WAN are plentiful, its disadvantages must be taken into account. For instance, while SD-WAN should decrease connectivity costs in the long term, the cost to license SD-WAN software is a near-term consideration. Adding a layer to the WAN could introduce an opportunity for new vulnerabilities that must be closely monitored and managed. SD-WAN will likely require companies to procure connectivity from multiple providers, which could add to IT's portfolio of service contracts they need to manage. Organizations can't overlook the expertise needed to deploy and manage SD-WAN technology properly, despite the fact that many vendors describe SD-WAN as a do-it-yourself technology. While vendors have tried to simplify most processes surrounding SD-WAN, IT teams still must think carefully about requirements for each feature they want to roll out, as well as plans for overall security.

10. SUMMARY

The integration of digital technologies into education represents a significant evolution in the pedagogical landscape, with the potential to enhance accessibility, engagement, and personalization in learning. This review synthesizes current trends, challenges, and innovations within digital learning, emphasizing the impact of artificial intelligence (AI), virtual reality (VR), and online platforms on student achievement. It highlights the importance of addressing technical, pedagogical, and socioeconomic challenges to ensure equitable access to technology. Successful initiatives like the Open University illustrate digital learning's potential to improve educational outcomes. The review also anticipates future directions, including the expanding role of AI, VR, mobile learning, and blockchain in education. It concludes with strategic recommendations for educators and policymakers to adopt best practices, prioritize infrastructure development, and focus on continuous professional development to leverage the benefits of digital learning. As education enters an era of digital transformation, a collaborative approach among stakeholders will be essential in creating an inclusive and effective learning environment for the future.

Our daily lives would be unimaginable without the advancements made possible by modern technology. It is seen as a foundation for economic development. An economy that lacks technological advancement is doomed to stagnation in the modern world. This is due to the fact that technology has made our jobs simpler and more efficient. Education is one of the many fields where the effect of technology may be seen.Every day, technology is transforming the way people work, play, and communicate. So it's only logical that new developments in digital technology are also transforming the educational landscape.

The term "educational technology" refers to any technology that facilitates active learning in a classroom. With the use of educational technology, teachers may design interactive digital textbooks and engage students via gamification, track attendance, give homework, and administer exams and quizzes that provide instant feedback on the effectiveness of their teachings. Learning in an environment that includes cellphones, computers, and tablets is upsetting conventional schooling and teaching techniques because of educational technology. Both beneficial and bad impacts of technology may be seen in schooling. Teachers and students should

take advantage of this in a positive perspective and minimize the limitations that are preventing many pupils as well as schools from realizing their full potential..

Teachers now have a wealth of resources at their fingertips because to technological advancements. “Assistive technology, virtual and augmented reality, high-tech collaboration tools, gamification, podcasting, blogging, 3D printing, artificial intelligence, customized learning, and much more are all generating a great deal of interest nowadays. Some of the most promising educational technology examples and trends will be discussed in this section. For starters, let's define what we mean by educational technology," as the term may be used to describe any of the following:•Educational approaches to learning theory and practise, as well as Information-gathering and knowledge-transmission technologies.

As the history of technology in the classroom demonstrates, technology integration in education teaches students the skills they’ll need in the future, including creativity, collaboration, and communication. Access to technology can lead to students taking more initiative and engaging with the content in every class they take.

Embedding technology in today’s classrooms, including the thoughtful use of AI, creates opportunities for students to become self-directed, adaptable learners both in school and beyond.

As a result, it is time for every nation to implement a more technologically advanced education sector in the near future.

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This book explores the transformative role of modern educational technologies and artificial intelligence in shaping the future of education. It provides a comprehensive analysis of how digital tools, online learning environments, and AI-driven solutions are reshaping teaching and learning processes across different educational levels and contexts.

The book examines key topics such as the challenges and opportunities of educational technology, the role of distance learning in developing soft skills, multimedia presentations for language learning, the use of YouTube in integrated lessons, and the implementation of electronic textbooks. It also addresses the impact of technology on classroom practices, the concept of social software, and the broader framework of information and communication technologies (ICT), including the role of open source software and internet services.

A significant part of the book is dedicated to artificial intelligence in education, covering AI techniques, intelligent tutoring systems, adaptive learning, computer-aided instruction, and real-world applications of AI in educational settings. The discussion also includes social learning theories and the evolving dynamics of digital learning communities.

Written in a clear and accessible style, this book is a valuable resource for educators, researchers, policy makers, and all those interested in the intersection of technology, innovation, and education.

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