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INFORMATION AND COMMUNICATIONS TECHNOLOGIES AND THE TRANSFORMATION OF LEARNING AND TEACHING PROCESS FOR THE 21ST CENTURY

INFORMACIJSKE I KOMUNIKACIJSKE TEHNOLOGIJE I TRANSFORMACIJA PROCESA UČENJA I POUČAVANJA ZA 21. STOLJEĆE

Velimir Topolovec, Marija Marinović, Mile Pavlić
Odjel za informatiku, Sveučilište u Rijeci, Rijeka, Hrvatska
Department of Information Science, University of Rijeka, Rijeka, Croatia

Abstract

Despite three decades of government initiatives and academic research, the use of information and communications technology (ICT) in learning and teaching remains only partially understood. This paper strives toward giving some evidence how new knowledge provided by cognitive, social, and learning scientists, information and computer scientists, and subject matter specialists studying learning and teaching has generated advances in our understanding of learning and teaching processes and contributes substantially to our understanding of how to use ICT to improve and transform learning and teaching. The production, sharing, and use of new knowledge and developments can dramatically improve and change the processes and outcomes of learning and teaching in 21st century.

S a ž e t a k

Unatoč tri desetljeća inicijativa i akademskih istraživanja, korištenje informacijskih i komunikacijskih tehnologija (ICT) u učenju i poučavanju, njihovo razumijevanje bilo je samo parcijalno. U ovom radu prikazat ćemo kako nova znanja stvorena od kognitivnih, društvenih, pedagoških, informacijskih i računarskih znanstvenika i specijalista u području učenja i poučavanja generiraju naše razumijevanje o procesima učenja i poučavanja i značajno pridonose razumijevanju kako koristiti ICT za poboljšavanje i transformaciju učenja i poučavanja. Proizvodnja, raspodjela i korištenje novih znanja i razvoja može značajno poboljšati i mijenjati procese i rezultate učenja i poučavanja u 21. stoljeću.

1. Introduction

Our society is boldly stepping into the "information age" and "knowledge age" which will change practically every dimension of our lives. It introduces new media, social structures, new goals, and changes the way we live and work (Table 1), create, learn, cooperate, etc. /**1**/

Modern information and communications technologies play the main role in these changes. The speed of creation, transfer and use of new knowledge demands a continuous effort and learning for nearly every kind of work or occupation. Due to this fact, learning and teaching processes need to be far more effective and efficacious, and the quality of learning and teaching becomes a necessity. The development of information and communications technologies opens various possibilities and approaches to implement these technologies in the process of learning and teaching. The aim of this paper is to emphasize that the implementation of innovative learning environments based on advanced technologies is the result of a strong connection between educational and cognitive theories, as well as technological opportunities and learning and teaching needs. The most salient results indicate that we can use technology to transform learning and teaching processes, and show discontinuous, rather than incremental improvements in education. These trends have various implications on the acquisition and transfer of knowledge in the 21st century.

1. Technology changes the way work is performed whether it's production, coordination or management.
2. Technology enables a greater integration of business functions.
3. Technology creates the possibility of the emergence of real global companies.
4. Technology speeds up basic changes in the organization structure.
5. Technology enables the transformation of organizations from „bureaucratic" to the so-called „webbed" or cooperative way of working or thinking.
6. Technology demands that the worker acquire new knowledge, skills and abilities.
7. Technology influences work place.
8. Technology provides empowers users and provides myriad possibilities.
9. Technology creates the possibility of the emergence of virtual organizations.
10. Technology influences the employee reward system.
11. Technology enables a quicker and more effective transfer of knowledge between workers and inside the organization.
12. Technology influences the acquisition of needed skills and knowledge.
13. Technology influences knowledge management.
14. Technology influences organizational learning.

Table 1 - Ways in which modern technology changes the work environment (Marquardt; Kearsley, 2007)

2. The development and classification of paradigms, models and approaches to learning and teaching processes with the support of ICT

In his book "CSCL: Theory and practice of an emerging paradigm", Timothy Koschman /**2**/ provides a new approach for the classification of systems using modern information technology in teaching and learning. This classification is based on Kuhn's theory of paradigm shift in the development of scientific areas. Koschman classifies the development of information technology use in teaching and learning into four paradigms: CAI (Computer Assisted Instruction), ITS (Intelligent Tutoring System) (Siemens, 2004; Toplovec, V.; Topolovec, A., 1989; Topolovec; Rosić; Pavlić, 1998), Logo-as-Latin and CSCL (Computer Supported Collaborative Learning). Table 2 illustrates main characteristics of these paradigms. /**3**/

The first three are older than CSCL and due to that they probably had more influence on the development, even though the theoretical framework is not the same. According to Koschman, CSCL is a new paradigm because it sets an unusually vast and interesting set of research questions and activates many researchers and devotees to find the answers to given questions and implement a fast application of the research results.

	CAI	ITS	Logo-as-Latin	CSCL
The meaning of the acronym	**C**omputer **A**ssisted **I**nstruction	**I**ntelligent **T**utoring **S**ystem	**L**ogo	**C**omputer **S**upported **C**ollaborative **L**earning
The event that marks the appearance of the paradigm	IBM course writer (1960)	Immigration of workers from artificial intelligence (AI)	Publishing the book S.Paperta:"Mindstorms" (1980)	CSCL NATO workshop (1989)
The theory of learning as the basis	Behaviorism	Cognitivism	Cognitive constructivism	Socially oriented constructivism, socio-cultural theories, cognitive-situational theories
Epistemological framework	Realist (knowledge is taken for granted) Absolutist (the teacher is the final authority)	Realist (knowledge is taken for granted) Absolutist (the teacher is the final authority)	Relativistic (nothing is absolute, it changes depending on time and space) Nothing can be taken for granted Knowledge is assembled through the process of subjective construction based on parts of experience, rather than discovering ontological reality	Relativistic (nothing is absolute, it changes depending on time and space) Nothing can be taken for granted Knowledge construction is a basic social process
Learning is…	The passive gathering or absorption of a built, and often strictly defined, set of information	A process in which a student acquires the correct understanding of a problem	New information interact with background knowledge and initiate the process of assimilation and adaptation	Cultural process which helps students to become members of new *knowledge societies* which have different characteristics than *knowledge societies* they already belong to
Thinking is…	Phenomenon inside individual's head	Phenomenon inside individual's head	Phenomenon inside individual's head	A number of different views placing thinking into a socio-cultural environment.
Research methods	Traditional methods of psychological experiment	Traditional methods of psychological experiment	Traditional methods of psychological experiment	Social and humanistic science methods

Research focus	Teaching efficacy	Teaching ability	Transfer of teaching content	A process rather than a result - main concern is connected to basic theories on observed data Descriptive rather than experimental Marked interest in understanding the process centering on the learner (learner discourse, group work results and learner self-evaluation)
Teaching model	Teaching becomes a process of transfer or delivery of teaching contents	Teaching consists of activities, designed in a manner to facilitate the acquisition of contents	Learning by discovery	Collaborative learning
The role of technology	Software… try to be simple and practical tool for teaching, built to satisfy the observed needs of a class	Designed software supports teaching in a way that it sets a problem and gives feedback to the learner	Computer creates a sort of environment in which the learner becomes the teacher, and the computer becomes the learner	The role of technology varies in relation to factors such as distance, software, implementation…
Application focus	Learning goal identification and their decomposition into tasks, development of a set of activities leading the learner through the whole learning domain.	Learning goal identification, decomposition of tasks and an interactive presentation in relation to present learner knowledge in order to initiate the process which will help the learner to achieve learning goals	Learning how to program in order to acquire understanding, which is beyond simple program coding	Cooperation with the purpose of initiating learning
Designer's basic knowledge	Teaching	Artificial intelligence	.	Social sciences

Table 2 - Paradigms of teaching and learning with the support of ICT

In his paper, Bottino R.M. /**4**/ lists three models of teaching and learning with the support of ICT: **(1) transmission model, (2) student-centered model and (3) participation model**. Transmission model is based on learning through exercise and repetition. The second model centers on the student and

demands his active role in research and construction of solution. Participation model emphasizes the importance of theories related to social groups, social nature of cognition and relationships between individuals in a group (theory of activity, distributed cognition, etc.).

Authors Toni Aviriam and Debbie Tami /**5**/ describe in detail three opposed clusters (paradigms) related to the classification of **approach [administrative, curricular (disciplinary and integrative), didactic, organizational, systemic, cultural and ideological] and of attitude [agnostic, conservative, moderate, radical and extremely radical]** according to processes of teaching and learning with the support of ICT. Based on this, they clustered many conference papers and projects related to processes of teaching and learning with the support of ICT. Three main opposed **paradigms (clusters)** are: **(1) holistic paradigm, (2) reformist paradigm, and (3) technocratic paradigm.** Table 3 illustrates their characteristics. /**6**/

	HOLISTIC	REFORMIST	TECHNOCRATIC
Will the education system remain the way it is now?	No	Yes, with certain didactic. modifications	No opinion (a positive answer is presumed).
Will the education system subsist?	Yes/No	Yes, with certain modifications.	No opinion (a positive answer is presumed).
Is the ICT revolution neutral or initiating?	Initiating	Initiating	Neutral
Is the ICT revolution predetermined?	No	Yes	Yes
Can ICT revolution be ethically judged?	Yes	Yes	No opinion.
Is the ICT revolution beneficial?	Yes/No	Yes	No opinion (a positive answer is presumed).

Table 3 - Opposed paradigms (clusters)

3. Learning environments

When developing modern learning environments, one should consider new findings in the field of cognitive science, psychology, pedagogy, computer science, information science and other sciences influencing the changes. These are **learning principles,** important **areas for research, development and practice,** and consequently the demand for **knowledge, skills and capabilities in the 21st century.** Of course, for an adequate learning environment, it is important to use an appropriate infrastructure (mobile, net, wireless 1 – 1 infrastructure).

3. 1Learning principles

a) The principle of conceptual knowledge

Learning and understanding is easier if new and existing knowledge is structured around main concepts and principles of a certain discipline

b) Background knowledge

Learners use existing knowledge to build new knowledge with understanding

c) Metacognitive knowledge

Learning is facilitated by using metacognitive strategies which identify, monitor and regulate cognitive processes

d) Learner differences

Learners have different strategies, approaches, abilities, competencies and learning styles which are a function of the interaction between their inheritance and previous experience

e) Motivation

Learner's motivation to learn and his self-awareness influence what will be learned, how much will be learned and the level of invested effort in the learning process

f) Situated learning

Practice and activities in which learners become involved; while learning they shape what is learned

g) Community learning

Learning is enriched through processes of socially supported interactions

1.	CRIT – Critical Thinking
2.	CRET – Creative Thinking
3.	CBA – Computer Based Assessment
4.	AIED – Artificial Intelligence in Education
5.	CSCL – Computer Supported Collaborative Learning
6.	PBL – Project Based Learning
7.	PSL – Problem Solving Learning
8.	LLL – Life Long Learning
9.	ID – Instructional Design
10.	TG – Talented and Gifted
11.	GP – Game Playing
12.	DL – Distance Learning

Table 4 - Areas for research, development and practice

3. 2 Areas for research, development and practice

Knowledge, skills and competencies for the 21st century

What follows is a list of EnGauge 21st century skills (Table 5) which represent a bridge towards original, intellectually challenging learner's activity. /7/

Digital-Age Literacy	
- Basic Literacy	- Scientific Literacy
- Economic Literacy	- Technological Literacy
- Visual Literacy	- Information Literacy
- Multicultural Literacy	- Global Awareness
Inventive Thinking	
- Adaptability	- Managing Complexity
- Self-Direction	- Curiosity
- Creativity	- Risk Taking
- Higher-Order Thinking	- Sound Reasoning
Effective Communication	
- Teaming	- Collaboration
- Interpersonal Skills	- Personal Responsibility
- Social Responsibility	- Civic Responsibility
- Interactive Communication	
High Productivity	
- Prioritizing	- Planning
- Managing for Results	- Effective Use of Real-World Tools
- Ability to Produce Relevant, High-Quality Products	

Table 5 - Knowledge, skills and competencies for the 21st century

When developing an appropriate infrastructure, every society should build its own strategy for the transformation of learning and teaching process.

4. Strategies: predicting, planning, organizing and measuring the influence of ICT on teaching and learning processes

Objectives tell us where we are going. Activities are how we get there. Strategies are

conjectures on the most effective ways to get to where we want to be. While these are all

important parts of any programme, it is essential to track whether or not we are moving towards these objectives and whether the activities and strategies are actually working. We need to know which aspects of our programmes are most effective and which elements are less successful or possibly even damaging. Knowledge of our performance enables us to improve our efforts and to share best practices with others. Only then can we hasten the collaborative process for making quality improvements in the effective use of ICTs in all forms of education.

To study and assess the actual impact of the utilization of ICT, UNESCO is conducting the Performance Indicators on ICT use in Education Project. Under the project, a structure of indicators to measure ICT use in education has been developed, providing a basis for policy planning and programme improvements. Specifically, the indicators demonstrate how ICT is raising standards in education, serving as a catalyst for educational change and empowering teachers and learners.

From 28-30 August 2002, Manila in the Philippines hosted a Consultative Workshop "Development of Indicators to Measure the Impact of ICT Use in Education." Thirteen participants from nine Asia-Pacific countries partnered to form a set of core indicators to assess the changes ICTs are effecting on education. Since the meeting, these indicators have been refined, revised and completed, and are currently being pilot tested in the participating countries. These indicators are shown in Table 6. Lately, more and more different approaches and models for **measuring the effect of ICT** on teaching and learning processes have risen in scientific literature and practice.

Component 1: ICT-Based Policy and Strategy	Component 2: ICT Infrastructure and Access	Component 2: ICT Infrastructure and Access
1. National/sub-national policy for ICT in education (formal and non-formal) 2. Master plan with a time frame 3. Budget plan and appropriations 4. Proportion of budget on ICT for education vis-à-vis national budget for education in US$, as well as ICT items/ activities on which money is spent 5. Organizational structure responsible for implementing the master plan 6. Scope and level of ICT programme 7. Monitoring and evaluation scheme or mechanism 8. Statement of inclusion of women, minorities, and those with special needs in ICT policy 9. If no ICT policy exists, manner by which the country and schools implement ICT for education 10. Existence of technology master plan in schools	**A. Enabling Environment** 1. Access to and use of electricity, computers, handhelds (PDAs), telephones, intranet, the Internet, TV/VCR/VCD/DVD, radio and other technological equipment by: a) number of schools and non-formal learning centres; b) number of students/ learners; c) number of teachers/school staff. 2. Number of computers per 100 students/learners. 3. Number of hours per week for ICT-aided instruction. 4. Access to and use of computers after school hours within and outsideschools. 5. Location of computers in schools/NFE centres.	**B. Internet Connectivity** Number of computers connected to the Internet either as stand alone or networked. 1. Kinds of Internet connection and speed/bandwidth. 2. Number of hours in a month schools access the Internet. 3. Source of payment for the Internet connection. 4. Access, use or possession of e-mail and websites by: number of schools, nunmber teachers and other staff (principal) and teachers. **C. Operating system and hardware** 1. Number of PCs running on various platforms (Windows, Linux, etc.). 2. Age of computers.

Table 6 - Indicators of ICT use in learning and teaching processes

Component 3: ICT-Based Curriculum	Component 4: Teaching Processes and Outcomes	Component 5: Learning Processes and Outcomes
1. Existence of a prescribed curriculum that incorporates ICT at all levels, both formal and non-formal, for minorities and for those with special needs (to be sourced from both national and school level). 2. Manner in which ICT is introduced or being taught in the school and the hours spent on its teaching. 3. Educational levels at which ICT is introduced as a separate subject. 4. Subjects into which ICT is introduced. 5. Purposes for which computers are being used for instruction in schools at the preschool, elementary, secondary and non-formal levels. 6. Extent of ICT integration in the curriculum. 7. Existence of software used for teaching and learning and source of this software.	1. Percentage of teaching professionals who acquired pre-service training on ICT (sourcing national and school levels). 2. Percentage of teaching professionals who received training in the last three years as part of in-service training. 3. Type of ICT training (basic, advanced). 4. Number of hours teachers are trained. 5. Purpose and frequency of use of computers by number of teachers. 6. Level of expertise in use of ICT. 7. Incentives for participating in ICT training. 8. Use of the Internet for teaching and how often.	1. Number of hours of ICT access and computer use: a) per learner per week for use in studies obtained from learner survey, and b) number of hours per year of computer use as calculated by the schools. 2. Number of learners with ICT access outside of school 3. Actual use of computers and related ICTs in subjects schoolwork. 4. Levels of skills in use of various ICT applications. 5. Source of learning of computer and ICT-related skills. 6. Use of ICT in schoolwork by number of learners. 7. Favorite uses of computers. 8. Access to Internet and how often.

Table 7 - Indicators of ICT use in learning and teaching processes (continued)

5. Perspectives

5.1(one-on-one) TEL (Technology-Enhanced Learning)

Forthcoming ICT technology defines the reach and limitations of the way it supports learning. Since the learning environment is marked by a shift from desktop computers to more widespread and powerful mobile devices, one can investigate new, powerful characteristics specific for **1-1 (one-on-one)** technology. Here, the term one-on-one **TEL (Technology-Enhanced Learning)** is used to describe a situation where a student uses at least one computer for learning. In some cases, students will be able to use more than one computer, or use computers with other micro-processor based equipment. It needs to be said that in ten years time, when every student will have their own computer as an inseparable learning tool, the term 1-1 will probably have lost its meaning. The role of personal technology will probably become so natural that it will become unnoticeable as well.

The term one-on-one (the concept in which every student has at least one computer) stems from the work of Elliot Soloway and Cathie Norris. On IEEE, WMTE 2002 and International Conference on Intelligent Tutoring Systems (ITS 2004), they argued that present "personal computers" are everything but personal for the students (learners) in schools: students often have to share a computer with others. They state that stepping into the age when every person could have afforded a pencil caused the whole learning system to change. Similarly, when every person could have had a book, instead of sharing it with others, again brought about the change in the way we learn. A similar change could occur when everyone will be able to have, and regularly use, their own computer.

A few researchers created a division of certain PDA characteristics, which are interesting for education /**8**/. These are:

1. Mobility, which enables the transfer to different locations from a computer, and enables moving

around the location, causing the classroom limits to extend to a wireless network range.
2. Social interactivity enabled via mobile and wireless technology which enables direct peer-to-peer communication, data exchange and interaction and face-to-face cooperation.
3. Setting personal research paths.
4. Contextual sensitivity which automatically records and collects the use for designing cooperative filtering systems and predictable user interfaces.
5. Connectivity which creates a real *sharing environment* via regular *data collecting network* between distributed devices.
6. Combining digital and physical worlds with sensors, intelligent rooms and ambient environments which seize real-world information from the user, devices and locations (geographical system of information) and represent these in a digital format.

5. 2 Neomillennial learning styles

Dede /**9**/ in his research elaborates possible future trends in the shape of neomillennial learning styles. These trends have various implications on the acquisition and transfer of knowledge and skills in the 21st century.

Which learning styles will emerge due to the life style based on media in 21st century? Research on educational MUVEs (Multiuser Virtual Enviroment), and augmented realities suggest that the following may emerge as cross-age learning styles:

- *Fluency multiple media, valuing each for the types of communication, activities, experiences, and expressions it empowers*.

This goes beyond millennial learning styles, which focus on working within a single medium best suited to one's style and preferences.

- *Learning based on collectively seeking, sieving, and synthesizing experiences rather than individually locating and absorbing information from a single best source*.

This goes beyond millennial learning styles in preferring communal learning in diverse, tacit, situated experiences over solo integration of divergent, explicit information sources and in valuing knowledge distributed across a community and a context as well as within an individual.

- *Active learning based on experience (real and simulated) that includes frequent opportunities for reflection (for example, infusing experiences in the Virtual University simulation [http://www.virtual-u.org/] in a course on university leadership)*.

This goes beyond millennial learning styles in valuing bicentric, immersive frames of reference that begin with direct participation, then infuse guidance.

- *Expression through nonlinear, associative networks of representation, rather than linear "stories" (for example, authoring a simulation and a Web page to express understanding, rather than a paper)*.

This goes beyond millennial learning styles by using presentations which include richly connected, positioned simulations rather than branched, but mainly hierarchical multimedia.

- *Co-designing learning experiences adjusted to personal needs and preferences*.

This goes beyond millennial learning styles, which emphasize selecting a pre-customized variant from a range of services offered.

Mediated immersion likely has other influences on learning style yet to be discovered, but these initial findings have a variety of implications for strategic planning, investment, and professional development in higher education. /**10**/

5. 3 Connectivism

Behaviorism, cognitivism and constructivism are three teaching theories used in creating learning environments. These theories were developed when the learning process didn't use ICT. Behaviorism, cognitivism and constructivism, as learning theories, were dominant when computer use and World Wide Web were still in the initial phase. George Siemens /**11**/ argues in his paper that these theories are not applicable to the present environment in which students learn. Technology reorganized our life styles, ways of communication and ways of learning. He suggests that a new learning theory is accepted for the digital age, called: **Connectivism:** ***A learning theory for the digital age.***

G. Siemens argues that behaviorism, cognitivism and constructivism focus on learning "within a person", and do not pay enough attention to learning which takes place outside an individual, as well as within an organization. G. Siemens claims that *including technology as well as connecting* become those learning activities which create a shift from present learning theories towards learning theories for the digital age. That is, using constructivism in a connected environment leads us towards a new learning theory which G. Siemens calls **Connectivism.**

5. 4 Adopting the revolution

Based on Rogers's research 1995 of technological diffusion of innovations /**12**/, we can suggest the acceptance of a prediction given by 17 authors /**13**/ about adopting technological revolution in teaching and learning processes. Figure 1 illustrates four phases of technological revolution **(IRRUPTION, FRENZY, SYNERGY AND MATURITY)** which are predicted in connection to ICT in teaching and learning processes for the 21st century. /**14**/

This technological revolution is gradually adopted. Some adopt it more quickly, and some more slowly, so the groups adopting the revolution can be classified as **EARLY ADOPTERS, EARLY MAJORITY, LATE MAJORITY AND LAGGARDS.** 1995. is used as the initial year (Figure 1) because it was the year Internet significantly spread to almost all areas of life. /**15**/

The first two stages represent the "installation period", with dream-based research. The last two phases represent a "deployment period", characterized by adoption-based research.

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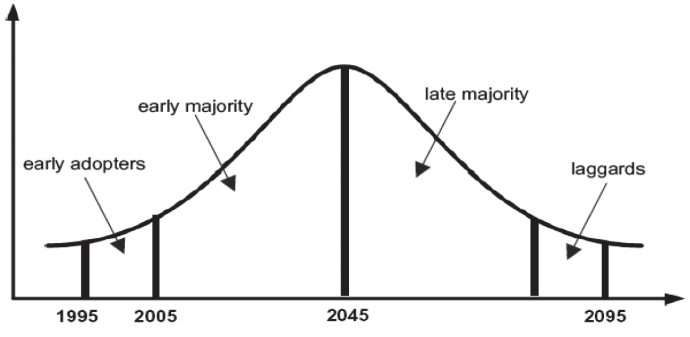

Fig. 1. Groups of adopters.

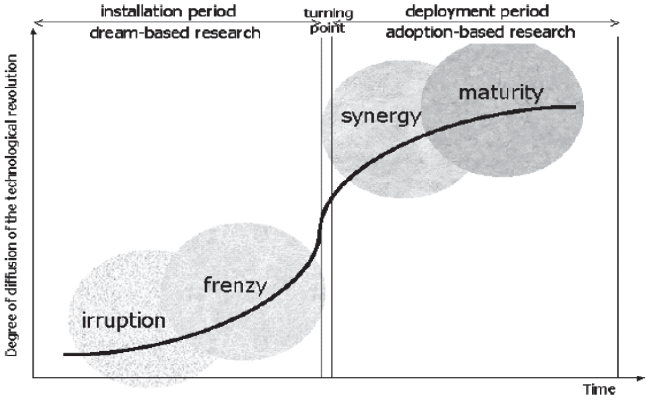

Fig. 2. Four phases of technological revolution.

Figure 1 - Revolution and its adoption

6. Conclusion

The paper shows different ways in which modern technology and the "knowledge age" change the work environment, which causes continuous effort and learning for almost all kinds of jobs and occupations. The paper shows paradigms of using ICT in the teaching and learning process, as well as main paradigm characteristics through different settings from different levels of abstraction. It also includes paradigms of the teaching and learning process with the support of ICT which are illustrated through different answers to the questions about education and ICT. The paper lists elements which influence learning environments, these being: learning principles (conceptual knowledge, background knowledge, metacognition...), areas for: exploration, development and practice (like:

remote learning, games...) and acquired knowledge, skills and abilities for the 21st century. The paper also illustrates indicators of the result of ICT usage in learning and teaching processes, which represent a sort of strategies and enable measuring the influence of ICT to learning and teaching processes. In the view of learning process development, different styles and learning theories are analyzed, as well as corresponding characteristics (one-on-one, neomillenial style, connectivism). New knowledge provided by cognitive, social, pedagogic, information and computer scientists and subject matter specialists studying learning and teaching has generated advances in our understanding of learning and teaching processes and contributes substantially to our understanding of how to use ICT to improve and transform learning and teaching. This progress has also led to constructing new architectures for interactive learning environments and a general confirmation that social context, motivation and teacher knowledge have an important role in determining the level of efficiency and reaching the desired effect. The production, sharing, and use of new knowledge and developments can dramatically improve and change the processes and outcomes of learning and teaching in 21st century.

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