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Competency Development and Innovative Trends in Engineering E-Learning

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Abstract
The article examines the main issues related to the innovation implementation into the engineering e-leaning. It presents the examples of using information technologies: micro-knowledge, animations, simulation, and chatbots.

Key words: e-learning, Internet-technology, competency, micro-knowledge, gamification, simulation, chatbot.

1. Introduction

In the middle of the 1990s mass-produced personal computers definitely became a personal tool for information processing. The first digital content was presented by electronical books including manuals, course lectures, and textbooks. It was the first study materials – prototypes of modern e-learning programs. The term itself "e-learning" was introduced in 1997 by Aldo Morri and Jay Cross, pioneers in this field. Along with the economics and management, new dimensions in engineering e-learning have recently emerged.

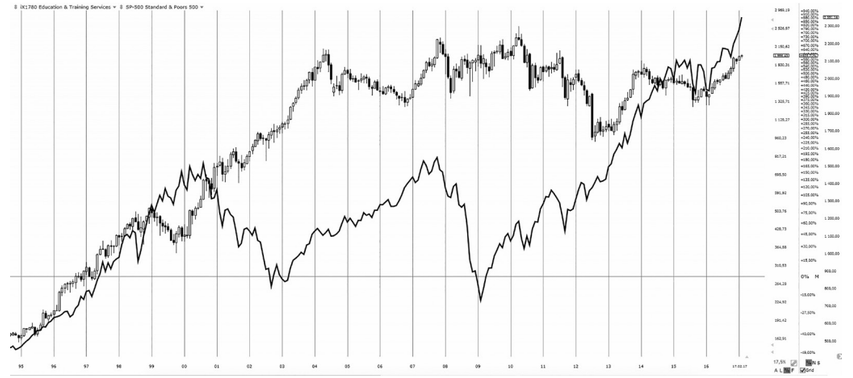
2. Internet technologies in e-learning

Despite the fact that the first computer-based education systems were invented in the 1970s, an explosive growth of using computer in education was seen only three decades later and primarily stipulated by mass introduction of internet technologies and boom of so-called dotcom (dot-com, dot.com). The term "dotcom" is referred to the companies whose core business is entirely internet related. As is obvious from the graph, since 1997 the index of public companies engaged in education and training programs has steadily increased over the past 10 years. The slight decrease was stipulated by the dotcom crisis in 1999-2000. It is worth noting that the crisis lasted for about three years (fig. 1), however, the index of "Education and Training" sector recovered just in a year. This fact proves the interest of investors in education sector. Over the next 10 years the index increased by over 600%. However, since 2004 the graph flattens out, and the period from 2010 to 2013 is marked by a steady decline of the index almost by 50 percent. Investors began to lose interest in e-learning sector.

China Online Education Group (COE), online English language learning resource, is a case in point. The company staff consists of more than 2500 employees. In June, 2016, the company entered the equity market and conducted IPO (initial public offering). As a result, the company attracted about 300 million dollars. However, the share of institute-related investors, the stock owners, accounts for 7 %. To compare, the share of institutes in the companies of the sector, which entered the equity market more than 10 years ago, make up 80-90%. This example illustrates the fact that investors began to consider the negative trend and carefully invest in the companies offering traditional products.

This can in part be explained by the economic crisis. However, investment analysts also indicate other reasons which relate to the peculiarities of education sector development. One of these reasons is a great number of free education programmes and open source software. This issue was addressed by marketing guru M. Porter in the article "Strategy and Internet" in 2001 [1]. The economic model of distributing free content leads to the situation when most profits are lost in the intermediate parties: communication service and internet providers. Due to monetization solution of online content, they deprive real producers of profit that they could spend on product development. However, as it turned out, free content, lack of reliable intellectual property protection, a wide range of piracy are not the greatest problems of online education. Investors believe that a steady decline in income from e-learning presents much greater problem. The investment analysts state three main reasons for this negative trend: damping of education services, too many standards and rules for applying e-learning in higher education system, and, the most important one, low interest of young people in traditional modes of e-learning, namely, electronic books [2]. The first two problems can be solved at political and economic levels. The solution of the third problem can hardly be achieved without introducing innovative technologies into education.

Fig. 1. Dynamics of index growth in "Education and Training" sector and Standrt&Poor's 500



3. Competency development and turn of education towards innovations

Innovations in engineering e-learning encompass several activities:

3.1. Micro-knowledge as a trend of engineering education

One of the ways to innovate e-learning technologies is to transform traditional courses into a set of so-called micro-knowledge. Simply speaking, micro-knowledge is a brief answer to one of the question covered within the course. The traditional lecture course is, as a rule, a continuous test with figures, formulas, and schemes. The lecture course based on micro-knowledge consists of numerous questions and corresponding answers. In fact, it is one and the same learning material, but it is represented in a different form. As is known, the form learning material is given plays a crucial role in education.

Cognitive scientists long ago gave attention to the fact that maximum concentration of a person on this or that question lasts from 6 to 10 seconds. To hold somebody's attention, it is required to constantly switch to something new within the discussed issue.

ENGINEERING EDUCATION 22'2017

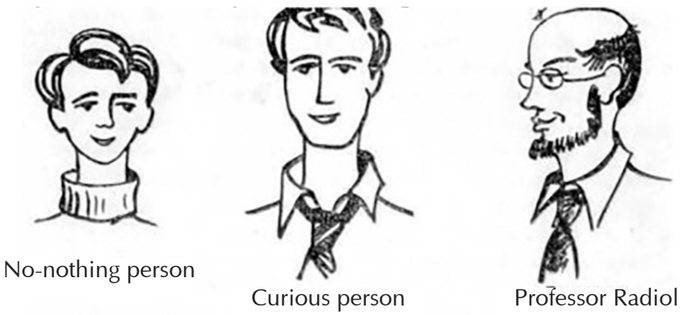
Such approach has been used in cinematography for a long period of time. It seemed that it would be possible to capture the entire dialogue from both characters using one camera (as it was done in old films). In modern cinematography, scene is shot from three or four perspectives followed by assembling the shots so that long shots change every 5-10 seconds.

Division of lecture course into numerous questions and delivering them in terms of micro-knowledge sets are not absolutely new technology. As early as the 1970s, E.Aisberg, a French science communicator, published a book "Radio – but it's so easy" ("La radio? Mais c'est trиs simple!)" [3]. The book material is presented in a form of a conversation between a student and a professor (fig. 2). Due to the innovative approach to transmitting knowledge, this book was twenty-seven times reprinted in France and translated into 14 languages. Such popularity proves the fact that learning materials presented in a form of micro-knowledge, firstly, are rather effective and, secondly, attracted millions of readers who voluntary paid for their self-education. The latter is of particular significance in terms of the disputes about attracting investments and additional financial support into the education sector.

Since the first release of the book more than 40 years have already passed. Only mow, the teaching technology in a form of micro-knowledge has become an innovation in modern engineering e-learning. Such long period was absolutely necessary as this technology could be hardly applied within traditional education mode. The difference in teaching mode is absolutely natural. Traditionally, 2 or 3 questions are discussed during a lecture. It is difficult to image a lector giving the lecture which covers 20-30 separate topics. However, it does not mean that it is impossible to introduce micro-knowledge technology into traditional education system. Precisely, at National Research Nuclear University MEPhI this technology has been implemented in a form of interactive tests to assess knowledge acquisition [4]. Such tests allow instructors to assess the quality of knowledge acquisition in real time. Students knowing about a simple test at the end of the lecture are more motivated to listen to the lector more attentively.

The examples of using teaching technologies based on the micro-knowledge principles are all over the Internet. First of all, it is microblogs, messengers, and knowledge bases. One of the types of micro-knowledge is a frequently-asked- question page crafted by many websites. Modern students belong to the generation of people who grew up with the Internet. In everyday life, they seek and find most information and knowledge in

Fig. 2. Visual technology of transmitting knowledge by means of a conversation (E. Aisberg, a French science communicator, published a book "Radio – but it's so easy")



the global net, and it is this net that forms their peculiar type of information reception. This is actually one more argument for introducing micro-knowledge technology into e-learning. Obviously, the micro-knowledge technology is not a panacea for solving all problems related to the negative trends in e-learning. Alongside all the positive sides of this technology, there are certain limitations. It is not effective or it is almost impossible to use micro-knowledge technology in cross-disciplinary dimension, creative work, art direction, practical training, music teaching, painting, and many other disciplines when not only knowledge but also psychological readiness is important for making decision, for example, while assessing the risks in a real time in the security sector or stock trading within a certain trade session. At the same time, micro-knowledge technology is rather effective for most engineering programmes.

3.2. Animation in shaping competencies while studying dynamic systems

Animation is an ideal tool for explaining engineering processes, procedures, and dynamic systems. With animation, lectors are no longer required to spend much time and effort to describe and explain the statistical diagrams and schemes. For students there is no need to visualize the dynamic process presented in diagrams. In this regard, animation significantly facilitates information reception by making it intuitively comprehensible and simple. In some disciplines, for example, field theory, for a student it is rather difficult to visualize information acquired by means of a verbal channel. In such cases, animation becomes increasingly important.

When introducing animation into education, it is essential to consider a number of limitations. Precisely, overuse of animation at the lecture may result in a contrary effect: students start absorbing information much worse. Cognitive scientists explain this fact by a number of limitations that human brain has, namely incapability of human brain to perceive rapidly changing pictures. In such cases, repetition, slowdown or descriptive texts are recommended. In addition, traditional lecture could be delivered in a multimedia format.

Obviously, for the years of practice most faculty members have elaborated their own format of information delivery including the number of questions to be covered at a lecture, time to be spent on each question, and the number of illustrations to be provided. In the course of lectures, they are in contact with students and are able to estimate the way students absorb information, which illustrations are easy for comprehension and which ones require additional explanation.

Development of e-courses, when a lector is replaced by an animated character, is the next stage in introducing animation into the education. There are several causes which stipulate such innovative trend. Firstly, it is simplicity and availability of numerous animation software. Secondly, it is the cost. This is particular true for the content developers. They often have to negotiate everything with a lector, refine or even develop new visual materials, tackle issues dealing with a copy-writer, rights in the end product, royalty, etc. Thirdly, it is personal characteristics of the lector himself/herself. For media programs, diction, the pitch of a voice, physical description, style and behavior pattern are of significant importance. On television and at various international exhibitions famous actors have been frequently invited as lector-popularizers. Animated characters are intended to perform almost the same role. Finally, such innovations in e-learning as virtual classes, game-based learning programs, simulators, and augmented reality have also significantly contributed to the discussed trend. All these innovations in some way deal with 2D and 3D models, which make them much easier for comprehension and reception.

As it was mentioned, there are a lot of various animation software. The most advanced and popular are as follows: CrazyTalk, iClone, DAZ3D, GoAnimate,

Toon Boom, etc. Let us consider the possibilities of CrazyTalk as an example. It does not necessarily involve the knowledge of software engineering. To create an animated character, it is required to choose the suitable image, i.e. drawn character or real people. If necessary, it is possible to use own materials: illustrations, 2D-models and photographs (fig. 3).

CrazyTalk and iClone include special modules which automatically sync lip movement with imputed sound adjusting to various facial expressions (fig. 4). Animated video is created by combining the image, imputed sound, and facial expression in the editing module. Interestingly, the voice can be imputed through microphone or by printing the talking script. The special module Text-to-Speech (TTS) converts normal language text into speech and saves it as a file. TTS modules allow quickly and effectively developing various education programmes without attracting professional commentators. Engineering issues disclosed by such animated tools are easy for comprehension, which, in turn, hastens development of the required competencies.

CrazyTalk allows converting 2D-objects into 3-D ones, however, for this purpose it is better to use 3-D animation programs such as iClone and DAZ3D. These programs allow freely designing and assembling rather real animated characters (fig.2). They include gesture and motion modules developed using 3D-scanners and special sensors which are put on a real person. It allows 3-D models to gesticulate, move and speak as real prototypes.

The last versions of the described software have export module for 3-D models which allow using the developed models not only for animated videos, but for engineering training games.

The growing consumer interest in engineering training games has been given early attention by game developers. They intensively invest money in this sector and actively compete for the market share. A new term "gamification in education" referring to a new trend has been even introduced.

3.3. Gamification as a method to shape competencies within engineering programmes

The idea to use games in education process is not new, however, the entry of available, rather cheap and simple-to-use software stipulates the real boom in development of game-based programmes. The recent studies conducted in various research laboratories have revealed that efficiency of game-based programmes is 15-20 percent more than that of traditional ones. The game-based programmes are more actively applied in school education. According to the report from Project Tomorrow (2016), in 2010 only 23 percent

Fig. 3. Animated characters (2D and 3D-models) from CrazyTalk and iClone libraries

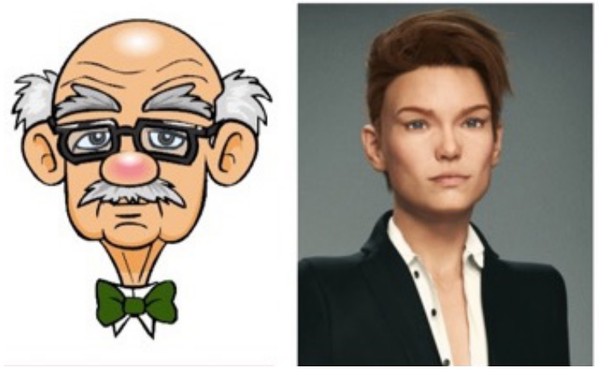
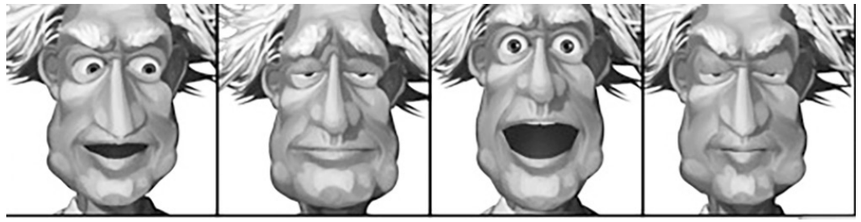


Fig. 4. Example of syncing imputed sound and facial expressions in CrazyTalk.



of teachers used game-based programmes in teaching process, while in 2015 this share increased to 48 percent.

In the opinion of most experts, games are introduced into education within the two main modes: gamification and the use of training games. What is the difference? Gamification is the use of game principles in non-game activities. For example, students are taught by means of interactive teaching material when it is possible to interact, pass the tests, monitor students' performance and move forward the next grade by means of mobile gadgets. All these tools are taken from the game industry and efficiently applied in education. American company GoGo Lab developed software program Rezzly (earlier 3D Lab), i.e. a set of services for course design based on gamification mode.

Another mode is development of training games. Most of well-known game developers have designed special software for developing education programmes. Precisely, Unity, a world leader in a game development sector, designed a special product Unity Educator Toolkit intended to be used as a tool to develop education programmes. The company provides opportunity to freely train how to use the tools of a new product, as well as offers discounts on education programme development tools.

Microsoft has also developed a new application Education Edition to its popular game Minecraft (the purchase price of game developer, Mojang company, was 2.5 billion dollars). By means of this application, educators can design the game activities related to the studied discipline including problem solving standards, interactive hints, statistics on student performance, etc.

4. Simulation in e-learning and engineering education

At the end of the 1990s, simulation was regarded as an absolutely urgent technology. This kind of innovation plays a crucial role in developing control systems for complex technological processes. Writing a software code was considered one of the basic problems that impeded introduction of this technology into education. To solve this problem, significant resources, investments and time were required. Modern simulation software includes a number of modules, each of which is intended to solve one of the typical modeling problems. Such software primarily includes iThink (www.iseesystems.com) [5] and AnyLogic (www.anylogic.ru). Working with this software is like Lego: a researcher has to build the studied model like from Lego units (fig. 5).

Simulation is starting to play significant role in education. The developed simulation software packages have become laboratory platforms for students to conduct various experiments, which is of particular importance in implementing and advancing e-learning.

4.1. Technology Chatbot in shaping engineering competencies

Lately the chatbot technology gains more and more popularity mainly thanks for the innate capabilities of the automation technologies and the widest outreach to

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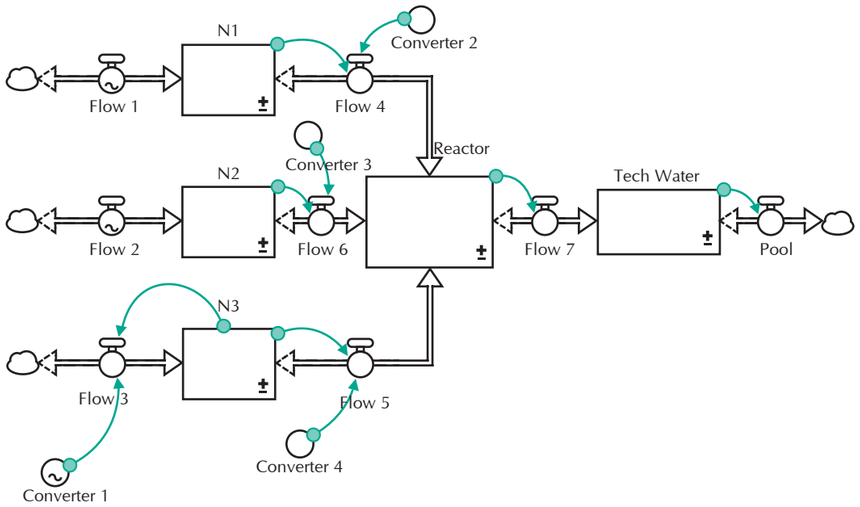
Fig.5. iThink simulation model for shaping engineering competencies



the audience [6]. In particular, about 700 million users per month take advantage of WeChat services. This innovation originated in business. Large companies have used such service as phone-tree (type of chatbot) for a long time. Practically everyone making a call may have heard: "If you have a question about – please press 1, if you are interested in ... – please press 2, etc. Thus, Chatbot is an interactive technology which is based on certain rules. A student poses a question, and computer-educator provides the answer. However, another version is also possible: a student is asked questions, while computer has to assess the answers. This technology has become widely applied in teaching foreign languages. English language school "Wall Street English" applies Chatbot technology in its multimedia e-learning courses. Due to this technology, more than 200000 students from 29 countries are annually enrolled into the school courses. In engineering education, the technology is not widely applied, it is all ahead.The first consideration of implementing new technologies into education is given in [7].

4.2. Globalization of engineering education programmes

Globalization is one more trend in engineering e-learning. Large players on the IT-technology market have not been spared e-learning boom. Such companies as Google, Microsoft, Apple have been developing their own e-learning courses for a long time. However, one of the main tasks of these companies is to become providers of a full set of services required for designing and disseminating e-learning courses. Having significant technological, informative, and financial resources, these companies are capable of designing and promoting a full set of services required for developing e-learning courses. In this case, users would have opportunity to freely take the advantages of the provided services, while the companies get profit from the monetization solution of online content: developers will be able to sell their content (training courses) by means of global online retailers of these companies giving them part of their profit.

5. Conclusion

Sustainable development of "Education and training" sector could hardly be secured without significant investments. Initially, investors invested significant amounts of funds into the companies dealing with design and dissemination of e-learning services and products. However, since 2010 the interest of the investors in this sector has declined. This fact can be explained by a number of reasons: availability of numerous free content, lack of reliable intellectual property protection, a wide range of piracy, damping of education services, too many standards and rules for applying e-learning in higher education system, and, the most important one, low interest of young people in traditional modes of e-learning, namely, electronic books. To reverse this trend has become possible due to innovative engineering inventions. The modern e-learning sets dramatically differ from traditional ones: digital books and training materials. In competition for education market, the companies actively apply innovative approaches implementing the latest inventions in the field of engineering information technologies and cognitive sciences. Simulation, especially simulation of technological processes and equipment, micro-knowledge principles, gamification, animation, augmented reality, chatbots and a number of other technological approaches are among the most widely spread innovations in e-learning.

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