NEWTON – Vision and Reality of Future Education

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***Abstract*—The paper describes selected progressive learning technologies and their experimental use in education. It relies on the partial results of the three-year NEWTON project (Networked Labs for Training in Sciences and Technologies) within the H2020 (Technology Enhanced Learning for STEM Education) EU program.**

It addresses specific modern e-learning methods, analyzing their principles as well as results of their pilot testing in different European countries that should either confirm or refute their pedagogical meaning.

Specific methods and technologies discussed in the paper include gamification, 3D technology, virtualization and FabLabs.

The individual progressive e-learning methods and technologies are analyzed in heavily heterogeneous pilot environments with regard to the age structure of the target group.

Keywords—FabLab, STEM, Modern learning methods, Virtual Reality, gamification

I. INTRODUCTION

Long time ago, modern approaches to education have crossed the boundaries of mere “electronization” of documents and their more or less public displaying online using various servers [1]. New techniques and technologies are entering the game, didactics and pedagogy are developing. The catchwords of the day are sharing, interacting and co-operating, as well as feedback in the teacher–student/learner relationship. All of this relies on using state-of-the-art tools, networking services and technologies.

II. NEWTON – PROJECT AND PLATFORM

Under the H2020 program, the NEWTON project [2] is currently being implemented, dealing with innovative methods and technology tools for modern forms of education. In particular, it builds experiments as linked existing laboratories, learning systems platform, and new learning processes, including a comprehensive system for evaluating their efficiency. The aim is to increase the quality of students’ knowledge, improve the learning procedures, and achieve more impact on student skills. Some partial project results and approaches to modern forms of education are described in this paper.

III. STANDARD OPTIONS

Currently, we can find a number of practices and tools on the education technology market that are routinely used and well known among teachers and students.

These include, in particular, the LMS (Learning Management Systems) which serve primarily (but not only) for direct support of attendance education. Their advantage is the long history of deployment (more than two decades), bringing enough user experience and widespread use. Basic functionalities, such as storage for learning resources, scheduling, testing, discussion forums, evaluations, etc., are gradually expanded by more sophisticated, less common elements, including such as interconnection with a school information system, more complicated testing functionalities (such as fill-ins, crosswords), functionalities supporting collaborative approaches to education, students’ mutual evaluation, etc.

Massive Open Online Courses (MOOC) constitute another already well-established part of modern education. Their history is about ten years old and the key idea is based on providing education to a very wide group of learners who do not have to meet any entry requirements and for whom the basic course is available for free. The course is based on the provision of educational content – often video lectures and other complementary materials – and on automated interactions with students (which is, however, not the only option) – this is the only way to serve thousands of learners or even more. Of course, the massive dimension, which is the basic attribute of MOOC, can be achieved in a homogeneous language environment (typically in English or other major languages), choosing a sufficiently attractive or general topic in conjunction with top-class lecturers. The production of a MOOC is quite expensive, beyond the possibilities of most educational institutions. On the other hand, recently we can observe the emergence of a large number of modest MOOC courses, which suitably complement the educational architectures based on LMS.

Yet another common part of today's modern education is the practice known as mobile learning, which does not in itself bring new quality into the learning process, but only applies already existing practices to portable terminal devices, i.e. mobile phones or tablets.

In the field of communication among students, the use of social networks has won wide popularity, especially for sharing experience concerning teachers and their courses, as well as for dissemination of elaborated tasks and so on. However, social networks have not been significantly used for communication towards teachers.

These features have contributed to the origination of the NEWTELP platform, which is designed to integrate all of the above-mentioned as well as below-described functionalities, forming a good basis for further expandability for new technologies.

IV. NEW WAYS

In the following sections, we describe some of the modern practices offer by the recent technological advances. We also evaluate their perspectives and possible – whether positive or negative – impact on education.

A. Mulsemedia

Mulsemedia represent the involvement of other senses in the HCI (Human-Computer Interaction) process. This is, of course, a general approach, narrowed down in this paper only to education applications. Usually, we mainly engage sight, to a certain extent with the help of hearing. We talk about mulsemedia when we involve also other senses, especially touch, smell or taste. Obviously, implementation of such approaches will be very challenging and the existing results are not simply reproducible.

On the contrary, it is easy to find practical applications – in the case of touch, for example, for people with visual impairments; smell helps us in education, for example in botany, viticulture or gastronomy where smells are very important.

Within the NEWTON project, learning experiments [3] have been prepared and implemented, which include the use of a haptic device, airflow generator and olfaction diffuser. These devices were placed on the receiving side of the system, being controlled by special (additional) data in a transmitted video stream. The purpose of the additional data was to activate cassettes with smells, fans, or other special devices. Several different scenarios were prepared for the experiment. Scenes from selected movies were presented to tested persons. Three scenarios included the use of only one mulsemedia effect, one scenario was designed for a combined mulsemedia effect. The smells were produced using the following aromatic tapes: Burnt Tire, Ocean and Diesel. The experiment compared the experience with mulsemedia effects turned off and on (according to a specific scenario). Most of the tested people (students) reported higher quality of experience by mulsemedia presentation of the scenes than without the mulsemedia effects. Of course, it is a question of how much the first mulsemedia experience influenced their conclusions.

B. FabLab

FabLab is an accessible workshop equipped with computer-controlled machines. We can find its origins at MIT around 2001. The goal is to produce “almost anything” in a small quantity, which is enabled thanks to a set of remote-controlled machines and equipment, such as cutter, milling machine, lathe, plotter, 3D printer, 3D scanner, or press. It should be noted, however, that FabLab equipment also includes conventional off-line components, such as a classic electrical workshop (manufacturing, assembly of printed circuit boards) or a mechanical workshop.

The community is roofed by https://www.fablabs.io. According to the current list (July 2018), there are currently 1293 FabLabs worldwide; compared with the past year, it means an increase of one hundred. In the Czech Republic there are 3 FabLabs (Brno, Liberec, Hradec Králové), but apparently only the one in Brno develops some activities. In this context, of course, the question is how much the number of thirteen hundred FabLabs worldwide is relevant.

FabLabs specialize in allowing those interested (not necessarily just schools) to access the modern technical facilities (mentioned above) and allow them to produce mostly small items of all sorts. It is clear that thanks to the usually excellent workshop equipment, this is a very motivating option for the interested learners and helps them to grow in many ways. Suitable areas for education include architecture (e.g. making building models), engineering (production of various components and smaller units), electrical engineering, IoT etc.; mostly it concerns technical disciplines. Users of FabLabs can access devices the devices in person (traditional approach) or remotely by means of electronic communications. The disadvantage of FabLabs is small throughput (given by a limited number of devices) and high operating costs that, if not subsidized by grants or other support, must be passed onto their users, which is problematic with pupils or students.

C. 3D

The third dimension of education is particularly helpful in explaining more complicated topics, such as propagation of electromagnetic waves, complex multidimensional models, spatial exploration of reliefs, architecture, etc. The technology is not new, 3D has been used over a hundred years ago. In the new era, however, it successfully merges with video technology and has recently experienced a relatively rapid expansion in connection with wide availability of the necessary equipment, when a common smartphone with an adaptor (so-called 3D glasses), that may be very cheap (priced from 10 EUR), is enough for decoding of 3D video. Another option is to use somewhat more expensive 3D glasses that work with compatible projectors.

While the first method is suitable for self-study (using a learning application downloaded to a mobile phone), the advantage of the second method is the ability to learn in the classroom, using a common projection of 3D materials; this way is also more convenient for users who do not have to wear a (rather heavy and clumsy) set of a mobile phone with a holder on their heads, but only glasses (standard size) with a receiver and some simple electronics.

D. Virtual Reality

Virtual reality is, in a simple case (similar to 3D glasses), mediated by a regular mobile phone with an adaptor. However, the learning application does not show a mere 3D model of the discussed phenomenon, but it introduces students into a fictitious reality in which they move more or less and the attributes of which can be influenced (controlled) somehow – for this purpose, glasses are often supplemented by drivers in students’ hands.

Within the NEWTON project, a 3D virtual reality learning application called “TCP/IP Protocol Model” was developed at STU in Bratislava. In addition to common virtual reality features, this application also includes some elements of gamification. Even the application guide for students is written in the form of a manual for a game, which also should increase its attractiveness.

In the virtual reality of the application, a gaming space with TCP/IP layer layers is created. There are quite a number of protocols, each of which belonging to a particular layer within this model. The students’ task is to learn which protocol belongs to which particular layer. For this purpose, individual protocols are gradually dropped around the playing field with the list of layers. The player is about to shoot the falling protocol just above the corresponding layer. The game has several levels of difficulty, and it contains also the success rate evaluation. The relatively simple graphics including a detail is shown in Figure 1.

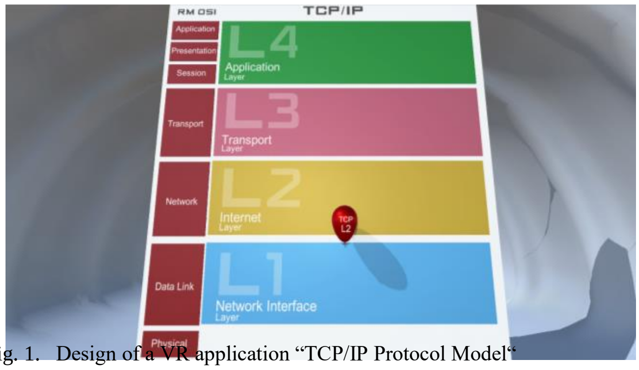

Fig. 1. Design of a VR application "TCP/IP Protocol Model"

During the pilot testing, this learning aid was very well received by students (tested at schools in Slovakia and the Czech Republic, among others). After comparing the acquired knowledge, students who had used the VR application had better knowledge than students in the control group equipped only with printed study materials.

At present (July 2018), very expensive glasses for 360° virtual reality (priced over 6000 EUR) are coming to the market, equipped with hand motion sensors (thus eliminating the need for handheld drivers), voice control, surround sound system, and an ultra-high resolution display (5120 x 1440 pixels).

E. *Augmented Reality*

Augmented reality has not been used for education on a wider scale yet. It combines a real student's view of specific objects with complementary, electronically-supplemented information that, for example, describes the properties of these objects. The descriptions are inserted into the real image through augmented reality systems e.g. through glasses. Considering that the augmented reality glasses are still somewhat unwieldy and large or too expensive (thousands of EUR), a smartphone or tablet is often used as a display unit. In this case, the camera of a tablet (or a phone) scans the scene in front of it (i.e. in front of its user) and the augmented reality system inserts additional information about real-world objects into the picture.

For the purposes of education, augmented reality is very beneficial. For example, it can combine a realistic view of a complicated technology (such as power plant control room) with descriptions of the individual devices and apparatus. Similarly, it is possible to combine e.g. a view of the interior of a passenger car with an explanation of the function of all individual elements.

F. *Gamification*

Gamification as a method of education goes further than the virtual reality (see the description of a game in section "Virtual Reality" above). Here we mean the application of gaming mechanics to the whole learning process [4]. So, it will be not just a specific application of a game in education, but the process when a student turns into a player with all the usual attributes of a game: bias, motivation, clear objective and vision of winning. In gamification, the following should become part of the learning process (and of the game itself): ratings (points), badges, levels, progress indicators, rankings and virtual currency. All these serve to compare students' performance (mutually), but also the learning progress of a student (individually). Gamification of education should create a virtual hero, the person whose story students want to share.

A good learning game should also allow personalization, i.e. dynamic adaptation of the difficulty of learning (game) to the student's abilities. Team games also appear to be very inspiring, where the element of competition among students is demonstrated even more.

Gamification foresees that an overwhelming majority of students will be interested in this way of learning; however, this assumption has not been confirmed. Rather, it can be expected that – as with other approaches to education – there will exist a relatively large group of students for whom it will not be satisfying.

G. *Multimodal Approach*

The multimodal approach also belongs to the category of HCI systems, and as such is not a revolutionary novelty. It relies on voice interaction, motion control, and various recognition techniques (fingerprints, eye iris, and face). These techniques themselves generally improve human-computer communication, thus improving the quality of learning; however, much more important is the so-called multimodal fusion, that is, simultaneous control of multiple modalities, such as a combination of voice commands and mouse movements. Experiments have been introduced in [5] showing that when two modalities are used for data processing, applying of an advanced fusion engine significantly increases the probability that human input commands toward a computer are recognized correctly.

V. CONCLUSION

New learning opportunities can generally be viewed as expanding practices or technologies. They should not be expected to change education in a similar way as we could see through the past two decades thanks to the progressive use of LMS systems and systems for MOOC courses [6]. They will be often applied in specific areas – for example, FabLab can only be found in technical subjects. The new ways of education have one common disadvantage – their production is highly expensive and their use is rarely universal. As far as their pedagogical impact is concerned, it can be considered as a success – also according to a number of practical surveys currently underway in the Small and Large scale pilot courses within the NEWTON project. Groups of students who participate in the lessons involving new techniques and tools show better results and more progress in acquired skills than those who attend standard lessons without using these tools. This is why we expect gradual integration of the above-mentioned procedures and technologies into common educational process.

ACKNOWLEDGMENT

This paper has originated thanks to the grant support obtained from the EC within EU Horizon 2020 (Technology Enhanced Learning for STEM Education) project "Networked Labs for Training in Sciences and Technologies); project ID: 688503, funded under H2020-EU.2.1.1. – INDUSTRIAL LEADERSHIP – Leadership in enabling and industrial technologies – Information and Communication Technologies (ICT).

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