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Using a Virtual Learning Environment as a Key to the Development of Innovative Medical Education

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Abstract. This article shows the organization of distance learning, particularly the idea of b-learning, combining the accomplishment of classes carried on in the traditional way and via computers. The authors present learning activities related to complementary education herein. Some of these course types may be successfully adapted to an e-learning background. The models and structure of the university virtual environment for distance learning are described. These illustrate a new approach to creating a virtual space for medical and technical studies where e-learning courses are created to be used for distance education, which allows students to be taught more effectively. The projected virtual courses for different groups of students ensure individualization of students' work, which could be a relevant element for creating the shortest path of development of professional competencies. This paper further includes a brief overview of technologies used to build interactive elements into learning materials. The authors present the use of interactive elements in medical education based on examples of certain selected games and animations.

Introduction

E-learning is now developing very rapidly due to the increasing interest in various forms of education. Wide access to the computer and the Internet is causing distance learning to become an increasingly popular and accessible form of teaching.

At the present time, the acquisition of knowledge is very important. This has strong links with raising professional qualifications, as well as broadening interest. Traditional forms of teaching are gradually ceasing to be sufficient. As a result, teachers are looking for new ways to transfer knowledge to

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students and check their skills. Hence, more often and more eagerly are we learning via the Internet.

Despite the facilities offered by distance learning (opportunity to learn anytime and anywhere), it will never displace traditional teaching. Direct contact between teachers and students is irreplaceable. Hence the emerging proposals for a combination of both forms (b-learning), which offers great opportunities for both students and teachers.

There are currently many programs supporting remote teaching on the market. Thanks to these programs we can develop entire e-learning courses that can be exported directly to the educational platform according to the relevant standards, such as SCORM. We can also create modern tests and various quizzes to check students' knowledge.

Blended Learning (B-learning)

The most efficient learning process consists of supporting traditional teaching with e-learning methods. Classes conducted in traditional educational institutions are complemented with virtual labs. Teachers provide a variety of materials, guidelines and instructions using distance learning techniques. This method works well for those who do not fully understand a particular part of the material. By learning in blended mode, a learner is able to revise and consolidate individual issues.

Models of B-learning Courses

Complementary courses use e-learning methods, work styles, and methods and styles of traditional fixed-line operations in the educational process. An exemplary course schedule consists of three stages (Figure 1):

- electronic training, during which basic theoretical information is transmitted,
- traditional training based on knowledge acquired in the first stage, which allows one to gain practical skills (direct participation in the educational process),
- an e-learning course, which is designed to consolidate knowledge, through the use of repetitions and complementary materials, skill-sharing in the context of discussion, as well as testing knowledge with tests and tasks. The aim is to identify future tasks and provide a final evaluation of the student.

Figure 1. Model of three-stage complementary training

There are also five-step training models. The first step, which takes the form of direct contact between teacher and learner, is to provide the purpose of training and its organization. The second, third and fourth steps have the classic form for blended learning, which was presented in the discussion of the previous model. The final step – the fifth – is carried out by means of a direct meeting. It aims to evaluate the teaching process. In this step, participants receive a certificate of completion of training (Półljanowicz et al., 2008).

Distance learning is a specific method of teaching where teachers and students are not in the same location. They can be in two different places in the world, but by using traditional as well as modern methods of communication, such as sending voice, video, computer data and printed materials, it is possible to conduct classes. Regardless of the distance between student and teacher, contemporary technologies enable direct contact in real time via audio or videoconferencing (Kubiak, 2000).

Traditional education can greatly benefit from introducing elements of e-learning. Many of the solutions derived from this form of education can successfully support traditional school activities. This represents a kind of hybrid learning, which brings together the advantages of traditional teaching and e-learning, so-called blended learning (b-learning). Such a combination helps to minimize some of the disadvantages of school education. An example might be a problem connected with a lack of uniform level of knowledge in the training group.

The teacher usually directs his or her lecture toward the average listener, which causes individuals below average to be lost (they are not able to keep up with the material), along with those who are above average (they don't fully use their abilities). Another problem, which e-learning can solve, is a lack of time during the course to transfer necessary knowledge, use it to perform various tasks and properly revise the material. Therefore, classes are held mainly to transfer knowledge and develop skills and the repetition and consolidation of issues is the individual work of listeners. There are even more such problems, for example education of the disabled and the sick. All these cases are difficult to solve within the model of a traditional lesson. Hence, it seems reasonable to refer to the support of e-learning (Półljanowicz et al., 2009; Rybak et al., 2009).

E-learning and B-learning as New Forms of Gaining Knowledge

E-learning is a relatively new form of education, created by the development of new technologies, including computer networks – Internet, multimedia, ICT. The interest and development of this form of distance learning over the past few years can be described in several aspects:

- From the perspective of economics, the prestige and importance of education is growing; it is estimated that the cost of distance education in the first year of study may be higher than cost of traditional education but there is a return on the investment during the next years of education.
- Technological – There is increasingly wider availability and cheapness of computer networks, especially the Internet.
- Educational and organizational – Due to its fast growing number of students and the opportunities offered for improving their professional skills through this medium, the competitiveness of the educational offers of universities, training companies, etc. is increasing.
- Social – Universities, regions, countries and international organizations take the initiative to implement distance learning.

E-learning is addressed to all people without any restriction. Those particularly interested in this form of education are:

- people suffering from a chronic lack of time (managers),
- economically active people who cannot afford to take part in stationary education due to work, but who want to deepen their knowledge,
- people working shifts, who have non-regulated working hours,
- people with disabilities and/or problems with mobility (problems for this group are deepening due to insufficient adjustment of the majority of Polish schools and universities for people with disabilities),
- people who live far from the centers of education and training, particularly residents of small towns,
- people who mostly stay at home for various reasons (for example due to caring for children) and who have only a few hours during the day to learn.

It can be concluded that the computer network, in particular, the wide area network (Internet), triggered an enormous change in communication activity. New specific forms of communication between people, such as chats, forums, and Internet telephoning came into existence. Therefore, it seems that distance learning is a response to society's willingness to introduce such forms of knowledge sharing in order to deepen interests and exchange information (Półjanowicz et al., 2008; Rutkowska, 2002).

B-learning is otherwise complementary learning that combines traditional education with the remote. Blended learning (mixed, hybrid) uses many advantages of e-learning and teaching in the traditional form. B-learning can be applied successfully in the education of students at "traditional" universities, as well as in continuing education of various social groups. This term is very flexible and is used to describe different teaching methods. Nowadays, we can assume that b-learning means an effective combination of different modes of delivery of educational content, according to a variety of teaching models and learning styles, and is based on a layer of communication between all parts of the process (Półljanowicz et al., 2005, 2008).

Areas of Teaching and Learning Activities Related to Complementary Education

In the process of teaching, a variety of class types are used, for example, course lecture, monographic lecture, auditorium exercises, projects, laboratories, seminars and consultations. A significant part of these classes can be easily transferred to the e-learning platform.

- Lectures on-line may be available in the form of a script (outline) or placed in the Internet as multimedia presentation. Typically, a lecturer transfers and discusses selected content in a single lecture, but by using an e-learning platform, students are provided with multiple opportunities to access this material, which allows them to extend and deepen the knowledge gained during the direct lectures.
- Virtual classes are usually conducted in a "traditional" way. They directly engage students participating in the class to solve a problem or contribute to a discussion. Implementation of this form of teaching in education involves the use of several modules of remote e-learning platform, such as tasks, tests (quizzes), chats, forums.
- Virtual seminars can replace traditional seminars supported by work on the distance learning platform.
- Virtual projects are the kind of teaching where students are especially active. Most of the virtual projects can be complementary to such forms of activity as exercises, lectures, homework, and labs. The availability of on-line projects makes it possible for the teacher to correct errors made by students at every stage of their work.
- Virtual labs are available in the form of simulation programs, multimedia presentations, video demonstrations, experiments, or allowing

control of real devices. They do not require expensive workstations in the laboratory. Using a virtual laboratory, students can make a suitable choice of the available materials (for example, students are allowed to choose the appropriate part of the material to learn or knowledge verification tests), which activates learners for further action. Knowledge presented in the examples, in the form of illustrations, animations, charts, additional descriptions and explanations (Hyla, 2005; Rice, 2010), is absorbed quicker and usually with better results. Sometimes repeating it a few times allows a person to solidify some important concepts from a range of material. Another advantage of computer-assisted learning is that the learner can assimilate the material given in the order and pace determined by them. This promotes independent, highly personalized learning.

– Consultation on-line – Contact with the teacher is available on the e-learning platform using tools such as forums, chats, audio and video conferencing, document sharing, virtual board etc. Most of the LMS/LCMS tools are designed for this type of consultation. On-line seminars can replace traditional seminars supported by work on the distance-learning platform.

Another goal of blended learning is to place virtual collections of tasks, example projects and of tests of knowledge on the e-learning platform. However, the use of tools to assess students, including final examinations and online colloquia, should ultimately be carried out in the presence of a teacher conducting classes (Półjanowicz et al., 2009).

Models and Structure of the Virtual Environment for Distance Learning in College

The structure of the virtual learning environment is shown in Figure 2. This virtual learning space model is the integral whole of all the methods and tools to ensure students the quality and effectiveness of distance learning (Kononowicz et al., 2010; Mokwa-Tarnowska, 2014).

The effectiveness of education is understood as the degree to which educational goals are met. We can also define effectiveness of teaching as an improvement of obtained results. The effectiveness of e-learning should include four levels of action: the level of response, the level of education, the level of behavior and the level of results that is characterized by the Kirkpatrick model (Kirkpatrick, 2009; Półjanowicz et al., 2011). Technical measures that are currently in use (modern e-learning platforms such

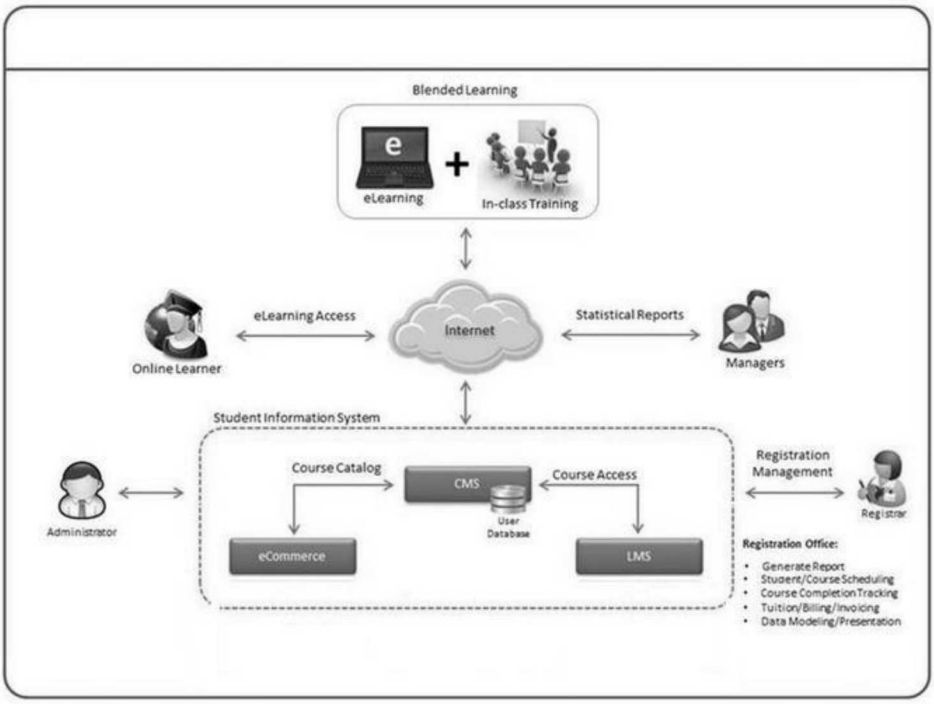

Figure 2. Structure of the virtualv learning environment (OpenSIS, 2014)

as LMS/LCMS, system servers, databases, broadband Internet access) allow to a new approach for designing the space of virtual science using the achievements of nano and micro technologies. Here we can use mobile devices such as netbooks, tablets, smartphones or mobile phones. In designing virtual courses for individual students, we should pay attention to current developments in vocational education, whose essence is to create the shortest path to the development of vocational competencies of a student who is learning in a virtual learning space. The essence is the optimal shape and size of content of knowledge transferred in the relevant modules by the lecturer and the related activity of learners.

The basis for building a virtual learning space based on modern means of communication is a set of ideas about the building and functioning of that environment (Virtual Learning Environments). The proposed model of a virtual learning environment for specific schools should include a coherent microassembly system for individual academic disciplines, which would be available within a broadly-defined repository (knowledge base) for students of various faculties. There could be elements necessary to acquire knowledge and professional competence, tasks and tests to check knowledge and exam-

ples of practical applications of acquired knowledge in practice (at work) in a variety of related scientific disciplines.

A discrete model of distance learning in a virtual environment (virtual learning space) at one or more universities in the city or the country should contain a set of mutually complementary information, at many levels of theoretical and practical knowledge, that would be available for students after logging on and after authentication on e-learning platform. This would increase attractiveness of studying different subjects because the students could freely determine what subjects they wanted to study in a given semester, having the gamut of different subjects to choose from. As a part of distance education, talented students, having free access to virtual classes, could realize additional classes thus gaining further specializations (Clarke, 2007).

The development of micro and nano technology makes building a virtual learning space easier for both providers and consumers of this knowledge. The security policy of a virtual learning environment, based on a series of securities (encryption of information, connections through VPN, access to only authorized users), ensures that users' data, materials placed on the e-learning platform, and the evaluation of remote learners are safe. As a part of the realization of classes of the individual subjects carried in the e-learning system, studies could be done to compare teaching effectiveness for classes utilizing e-learning with those taught in the traditional system. We do such research for selected subjects with students at the Medical University of Bialystok (Figure 3). The results of this research have shown that teaching with the e-learning method is comparable to the traditional method of teaching, and even gives slightly better results. The explanation for this consists of a number of factors, namely the all-day access to teaching materials unlimited in time, a number of tests evaluating students' knowledge assessed automatically by the system on the e-learning platform, direct discussion in groups in the forum, giving students the opportunity to exchange information with each other, teaching material prepared in the form of multimedia (graphics, animations), which shows some real physical and technical phenomena and processes taking place more effectively than with use of chalk and board (Półjanowicz et al., 2011).

In 2009, the University of Bialystok launched an e-learning platform – Blackboard – which is used to hold general courses included in the program of studies. Courses are held according to the blended learning format – one part is led in the traditional way, another in the virtual learning environment (VLE) (Figure 4).

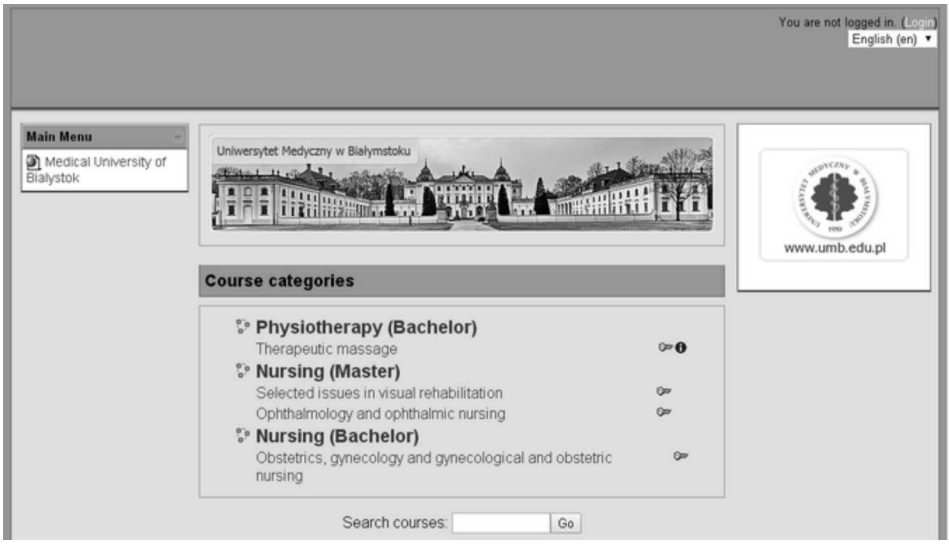

Figure 3. The main window of the tested e-learning platform used by the Medical University of Bialystok

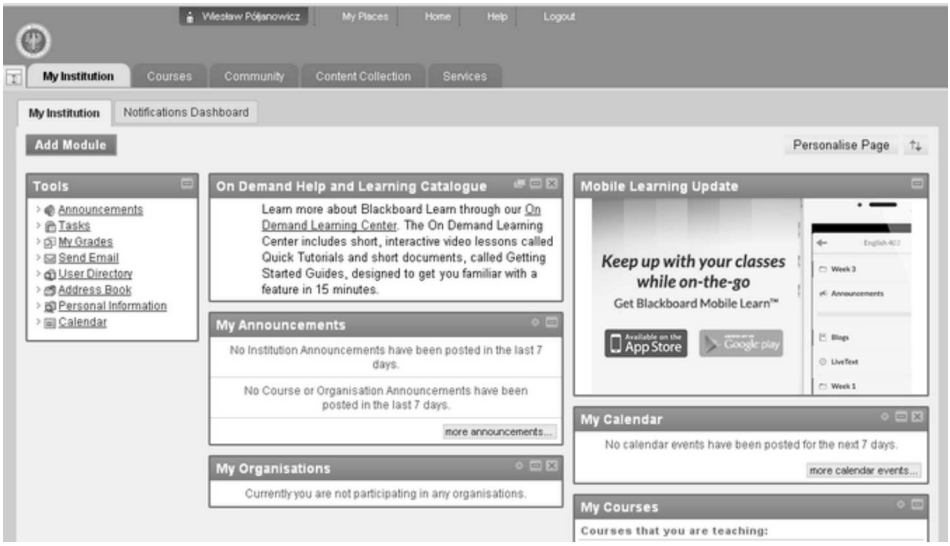

Figure 4. The window on the desktop of the e-learning platform Blackboard, used by the University of Bialystok

Interactive Elements – an Important Part of the Virtual Learning Environment

With the development of technology, more and more complex interactive elements can be created and better matched to the presented topics, such as simulations, learning games, decision labyrinths, or multimedia presentations. These items have a major impact on memorization processes, allowing the learner to grasp the issue more efficiently and rendering the presented contents more attractive. As such, they constitute a very important component of learning materials for distance education methodology. The authors present a brief overview of technologies used to build interactive elements and examples to illustrate their practical implementation.

Technologies of Building Interactive Content

At the moment, programmers have numerous technologies at their disposal for building interactive elements (Roszak et al., 2013a). Construction of interactive elements on websites is heavily supported today by technologies drawing directly from the possibilities offered by graphics cards. These are typically referred to as RIA (Rich Internet Applications). Computations, particularly in graphic designing, can be done by the graphics card processor (GPU). This is important for animations and games. Specifically, some computations in the application activity are done by the CPU of the workstation and some by the GPU. Below are some examples of contemporary technologies.

- Microsoft Silverlight – This technology is practically available only for Windows OS. The latest version, i.e. Silverlight 5, allows you to write 3D applications using XNA technology previously created by Microsoft for 3D game development. In its 2D version, Silverlight is used inter alia by LCDS (Learning Content Development System), a popular e-learning tool (Roszak et al., 2013b).
- Stage 3D is used in Adobe products, particularly Adobe Flash and Adobe AIR. Programming in Stage 3D is available on different levels. Generally, the hardware-supported graphic programming model is based on so-called shaders, i.e. short programs that communicate directly with the graphics card. Adobe has created two languages for shaders: AGAL (Adobe Graphics Assembly Language) – a low-level Assembler type language, and Pixel Bender 3D – a high-level shader language. Users who are not experienced in such programming may use

several ready programming libraries (commonly referred to as programming frameworks), which makes it much easier to create software. For 2D graphics, Starling (2014) is particularly popular, enabling the user to quickly create platform games. Alternatively, 3D applications can be developed with Away3D (2014), Flare3D (2014), Alternativa3D (2014), Minko (2014), or Mixamo (2014). All these programming libraries use ActionScript, a high-level object language by Adobe, popular in classic Flash applications. EasyAGAL (2014) is an alternative for Pixel Bender 3D.

– WebGL – a technology based on OpenGL ES library (current release 3.0), available in browsers through HTML5 canvas and JavaScript. Like Stage 3D, this type of application is fully supported by hardware. The shader language in this case is GLSL. Several frameworks are also available in this case, of which Three.js (2014) is particularly popular. WebGL technology can also be used on hardware without advanced graphic cards, however only with Chrome and Internet Explorer 11 browsers.

Mobile devices (smartphones, tablets, PDAs, etc.) support the use of most technologies available for PCs, the main difference being the significantly lower CPU computing power.

Educational Games – Examples of Interactive Content in Medical Education

A learning game is based on a scenario which should cover all or selected variants of the covered topic. The scenario is the aspect that differentiates a game from a simulation or another interactive element. For learning games, it should be coherent and well thought out so that the learner's attention is focused on important aspects in terms of educational value (Roszak et al., 2013a). Apart from the learning function, they have the following additional functions: motivation, simulation, and facilitating understanding (Margulis, 2005). The authors present several examples of games and animations developed for medical education.

Example 1 – Use of Silverlight Technology

Tile game is a refresher item for the topic of measuring scales used in statistical analysis of medical problems (Figure 5). Game scenario: the student is asked to separate phrases related to ordinal scale from other phrases. The phrases are put in two stacks. Every card in the game contains

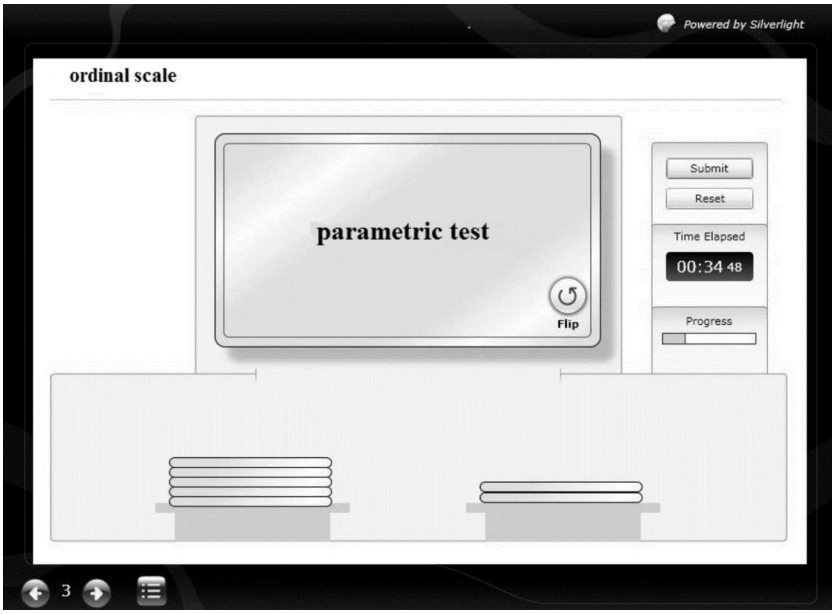

Figure 5. Tile game in LCDS for medical students

two phrases, one on each side. The student's task is to specify the right side of the card, containing the phrase related to ordinal scale. If the student gives a correct answer, the card will be put on the first stack; otherwise, the card goes to the other stack. The total time of the student's responses is measured. The game is accompanied by definitions of measurement scales and example medical problems in which these are involved.

Example 2 – Use of Flash Technology

Blood Type Game is an example of a game involving matching the donor's blood type with the recipient's blood type (Figure 6). Game scenario: the learner matches the right donor for the recipient's blood type, selecting the donor from several available options. The player's activity consists of selecting a blood donor for 10 different recipients in one round of the game. Each donor must be chosen within 10 seconds. Every right decision is scored. In the next rounds, the player receives a higher score for every correct answer but the time needed to make the decision is shorter. The game has a simple, user-friendly interface and the scenario, with shortening times for decision making, motivates players to put more effort into gathering the maximum score possible. A table is attached to the game, presenting all available donor/recipient blood type combinations. Blood Type Game is a simple game that effectively realizes its learning purpose.

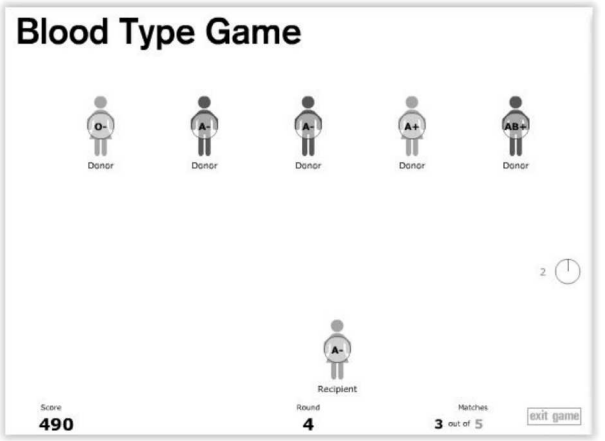

Figure 6. Blood type game (American Red Cross, 2014)

Example 3 – Use of Flash Technology

Virtual Knee Replacement Surgery (Edheads, 2014) is an example of a game presenting stages of knee replacement surgery. Game scenario: the user is in a hospital where he performs knee surgery under the supervision of a doctor. The player's activity consists of following the subsequent stages of surgery using the surgical instruments recommended by a virtual doctor (Figure 7).

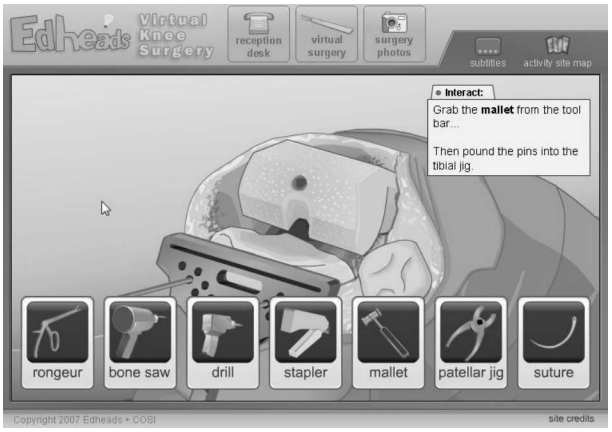

Figure 7. Example surgery screen with surgical instruments shown (Edheads, 2014)

During the surgery, the player answers questions about the given stage, and receives feedback from the doctor after selecting (clicking on) his answer (Figure 8).

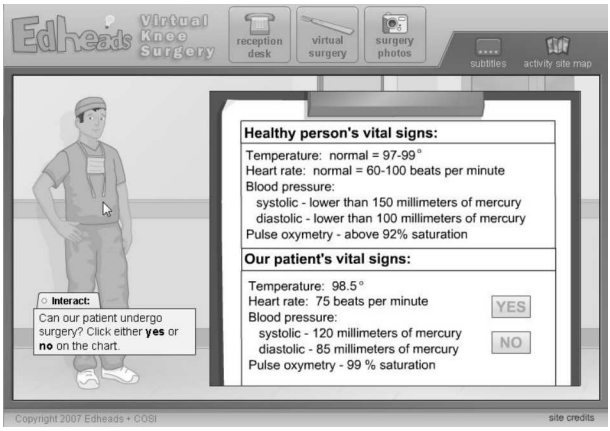

Figure 8. Sample questions that the learner is asked during the game (Edheads, 2014)

Attached to the game is a set of the patient's test results and photos of an actual surgery. (Figure 9).

Figure 9. Surgery photos (Edheads, 2014)

Virtual Knee Replacement Surgery is a game produced in Flash technology. The game scenario is based on actual knee surgery stages and allows the learner to learn about the surgical procedure and tools used. This game may inspire the development of similar interactive materials for medical students. Such materials can provide a training base before entering the actual theatre.

Example 4 – Use of WebGL Technology

WebGL technology carries the learner into another world of 3D application interaction and adds a new dimension to learning materials. Such applications can have a full 3D computer game functionality; specifically, they support free interaction with 3D objects – animation and modification. An example of such an application is an interactive Web-based platform, The BioDigital Human (2014), which was created to teach about the human body and is a very good resource to facilitate learning of anatomy for medical students and others. Students can view detailed 3D anatomy, isolate structures, view detailed anatomy descriptions, dissect, educate and explore, annotate and personalize; there are options available to bookmark and save, connect and share, and visualize health conditions. You can create a cross section. There are interactive animations, procedure guides and data visualization. Figure 10 shows available tools allowing the learner to present an object in standard, transparency or isolate mode, and others for producing a snapshot or a cross-section. During the course of learning, students can test their knowledge through quizzes with feedback, selecting the number of questions in a quiz (5, 10, 15, etc.). The project contains over 5,000 3D models to illustrate anatomy and health conditions. Examples from the platform are presented in Figures 10 and 11.

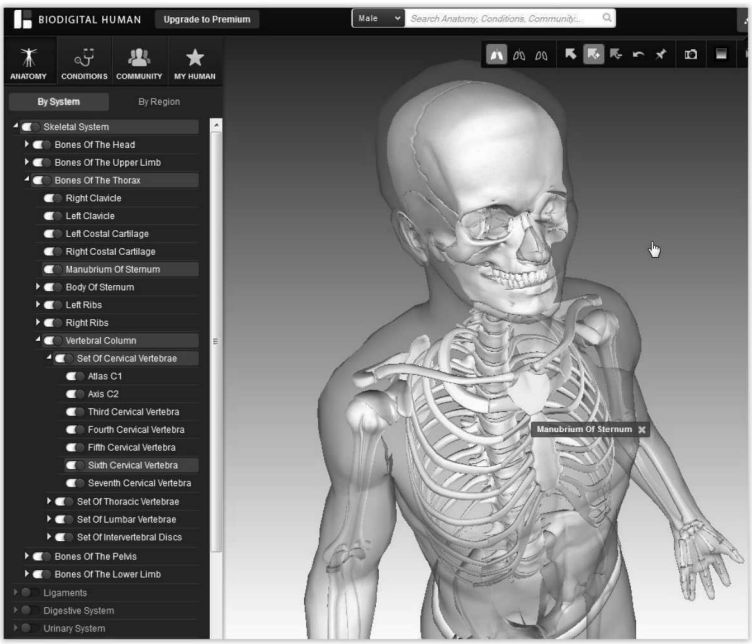

Figure 10. Skeletal System (The BioDigital Human, 2014)

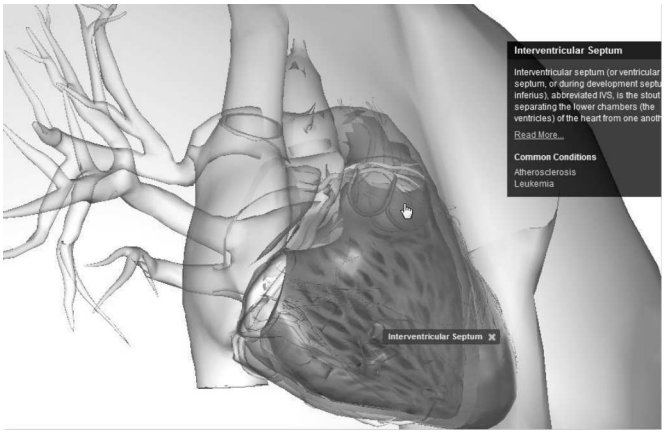

Figure 11. Heart Anatomy (The BioDigital Human, 2014)

Example 5 – Use of WebGL Technology

Another example of an application using WebGL technology that can be used for learning anatomy is the application called Zygote Body. It offers options to delve into the mysteries of the male and female body using a simple interface resembling that implemented in Google Earth (Figure 12).

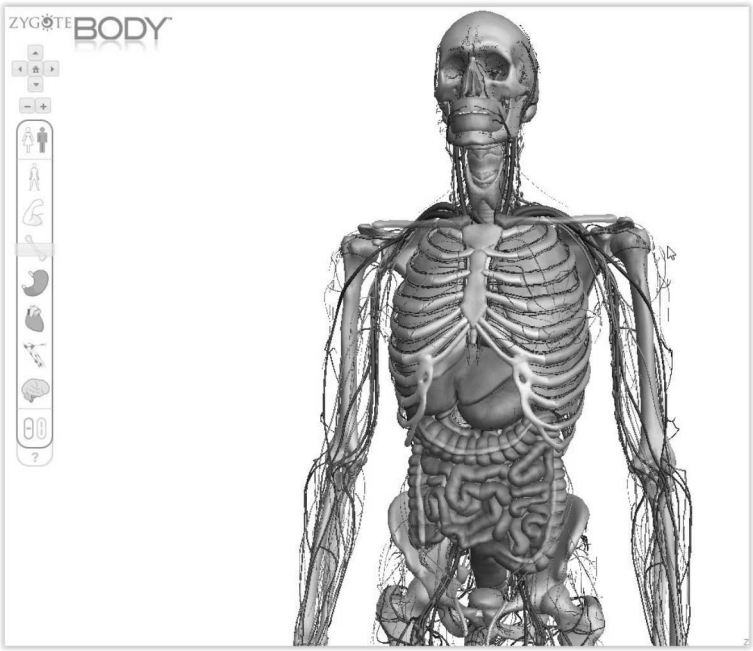

Figure 12. Example in Zygote Body (Zygote Body, 2014)

The user can enlarge, turn, move and zoom on selected elements, as well as add item names on a model (Figure 13). This facilitates refreshing the covered topics. This application is only one example created with 3D anatomy models from Zygote Media Group.

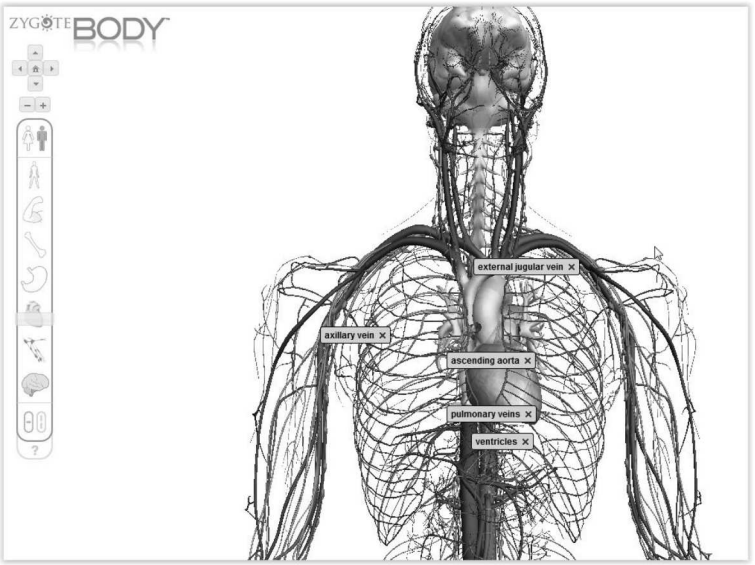

Figure 13. Adding item names on the model (Zygote Body, 2014)

Conclusion

Education as a whole tries to benefit from the opportunities offered by e-learning. Lots of interesting solutions coming from this form of education can assist traditional activities. Then, the blended learning mechanism comes into existence, which brings together the advantages of traditional teaching and e-learning. Such a combination helps to minimize some of the disadvantages of traditional education. One of them might be the problem of lack of time to provide necessary knowledge during classes as well as to use it to perform various tasks, and consolidate the material. Therefore, classes are mainly used to transfer knowledge and students are expected to develop skills and repeat and consolidate information on their own. We can list even more problems, for example, lack of uniform level of knowledge in the group. They all have one thing in common – they are difficult to resolve within the traditional model of a lesson. Hence, it seems appropriate to use e-learning education (Półljanowicz et al., 2009, 2011).

The usefulness of e-learning tools in the realities of universities is very high. However, they should be used in a specific way – to support traditional instruction. Use of e-learning tools is a very good method for providing additional necessary knowledge. The online platform also enables the involvement of students to perform various tasks and projects. In addition, pupils find this form of gaining knowledge more attractive. It increases their motivation and engagement in the learning process.

Learners' activities constitute an important part of the e-learning process. With the available technologies, you can build various interactive elements, such as games, simulations, multimedia presentations, video demonstrations or experiments. Use of such resources in teaching improves learning efficiency, as it allows learners to acquire knowledge more effectively and has a major effect on extending memory (Kowalewski et al., 2013; Roszak et al., 2013b). Nevertheless, it should be borne in mind that even elementary applications can only be created with the use of advanced technologies by users with basic programming knowledge, or by working with a team of programmers (Ren-Kurc et al., 2012).

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