

МЕТОДОЛОГИЯ ЗА ОБУЧЕНИЕ ПО МАТЕМАТИКА ЧРЕЗ 3D СЕРИОЗНИ ИГРИ

Мария Христова Монова-Желева

Янислав Панайотов Желев

METHODOLOGY FOR TEACHING MATHS THROUGH 3D SERIOUS GAMES

Mariya Hristova Monova-Zheleva

Yanislav Panajotov Zhelev

Abstract: *The paper presents a methodology for teaching Maths (especially Geometry) developed in the framework of two projects - the international project TALETE [9] and the project for the development of Burgas Free University /BFU/ Distance Learning Centre [12]. Aim of these projects is the improvement of the distance training and learning by development of modern instruments and methodologies based on the advanced ICT achievements with focus on the balanced integration of theory and practice.*

Keywords: *v-Learning, Blended Learning, 3D Learning Environments, Interactive Simulation, PISA Mathematization Cycle.*

Introduction

For monitoring educational progress at least three main concept areas need to be considered, namely: Intended learning outcomes; Opportunities to Learn (OTL); Competencies/attitudes of students. Intentions may be formally legislated in syllabi, examination standards or “Intended Curricula”¹, the study “Indicators on ICT in Education”. These constitute the basis for guiding a lot of educational processes, such as the content of the textbooks, teaching and learning activities in schools, the content of (in-service or pre-service) teacher training, etc. The analysis of these intentions is usually the basis for designing international comparative assessments that currently are run by international organizations, such as OECD PISA (Program for International Student Assessment) [6,7] and IEA TIMSS (Trends in International Mathematics and Science Study) [2,10]. These instruments can be used to improve teaching and learning methods and to favour innovative approaches to school subjects, especially to mathematics and science. They are complementary tools with the objective to assess different features of student learning.

TIMSS (Trends in International Mathematics and Science Study) is an international assessment of the Mathematics and Science knowledge of fourth-grade and eighth-grade students. TIMSS was developed by the International Association for the Evaluation of Educational Achievement (IEA) to allow participating nations to compare students' educational achievement. TIMSS measures the Mathematics and Science performance of 4th and 8th grade pupils.

PISA - Program for International Student Assessment, instead, measures the knowledge and skills of 15-years old pupils in reading, mathematics and science. Both of these instruments aim at collecting data at international level providing information to assist policymakers, researchers and the public authorities in order to give them a complete picture of how students perform in the school subjects.

¹ The study “Indicators on ICT in Education” was run under the auspices of EACEA (Education, Audiovisual and Cultural Executive Agency of the European Commission). The study is finalized in October 2009.

The worldwide surveys report that EU students often lack mathematical competence and key basic competences in science and technology. In this context Bulgaria is not an exception (Please see the figure below).



Figure 1. PISA 2012 Evaluating the school systems to improve education; <http://www.slideshare.net/OECD/edu/pisa-2012-evaluating-school-systems-to-improve-education>

Especially for Bulgaria the collected data shows little improvement reached but the average rate is still far from the desired data. Maths teaching is crucial for personal development and to help individuals to adjust to life in modern society. It is important, that future citizens understand the interrelationships between science, technology and other facets of society, including social and economical development.

In this context the higher educational institutions in Bulgaria are obliged to provide to the secondary school teachers of Mathematics flexible tools and methods for teaching which are in accordance with PISA, TIMSS and National Curriculum standards. On the other hand these methodologies have to assure attractive and motivating learning process for the students and thus highly to contribute for their mathematical literacy improvement.

In order to answer to this necessity a course for qualification improvement addressed to the secondary school teachers of Maths was developed. The aim of the course was to promote one methodology for teaching Geometry in 3D virtual environment. The course development and implementation was done via integration of the results and outcomes of the project for the development of BFU Distance Learning Centre [12] and the international project TALETE [9].

Learning and practice environment

The course was delivered to the teachers through hybrid learning environment comprising the e-platform of Distance Learning Centre of BFU and 3D TALETE virtual Constructivist Learning Environment /CLE/.

The e-learning platform (developed on the basis of open source platform Moodle) contains all necessary facilities for the e-learning process implementation. It was used in order to deliver the e-course, in terms of educational pills and the social area for the teachers.

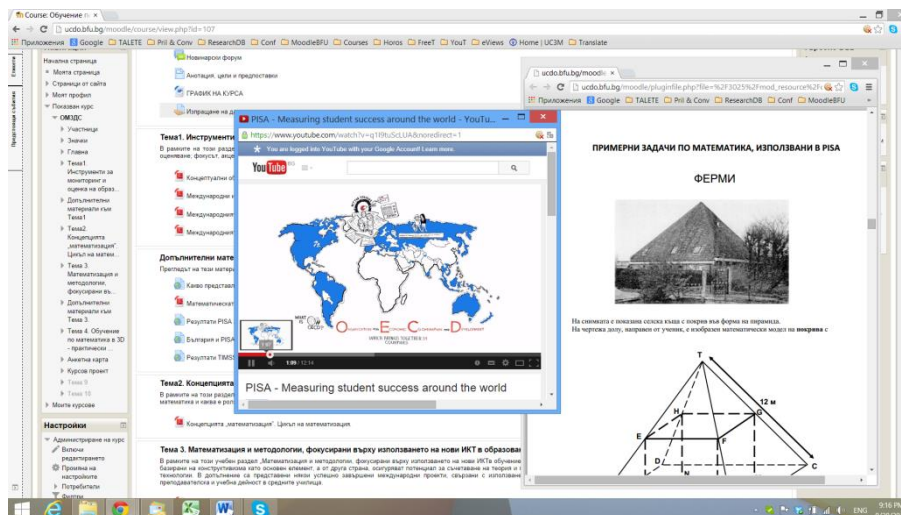


Figure 2. Screenshot of the course published in the platform of BFU Distance Learning Centre

The course content was presented via structured in recommendable order learning topics. Each content topic is explained in depth by appropriate examples - links to websites, videos, and documents. All learning materials could be downloaded and used also in off-line modality. Teachers also have the possibility to communicate with their mentor and with their colleagues via platform messaging system, e-mails, skype, phone calls and also face-to-face. Access to the platform is possible via username and password.

3D TALETE CLE contains the scenarios produced on the base of the assessment schedules previously selected by the TALETE project RET (Research and Educational Team). In this team took part Maths experts, experts in the technology of education, ICT experts and Maths teachers from Bulgaria, Greece, Italy, and Turkey – the countries participated in the successfully finished TALETE project. All assessment schedules are carefully selected in order to cover the standards of PISA as well as the National Maths curriculum of the partner countries.

Teachers login to the TALETE website to access the 3D virtual environment. An animated, 3D scenario plays at the opening to introduce the overall storyline. The participants arrive in a virtual kitchen (everyday context where maths' ideas are embedded) to unlock the challenges. The virtual world has been developed on the basis of the software platform Unity 3D. The challenges are specific mathematical problems covered by the topics of the National Curriculums of the partner countries.



Figure 3. Screenshot of the 3D TALETE virtual world.

The problems have been implemented as separate, but linked in a common scenario, mini-games. The 3D environment is a fully explorable 3D space, viewed by the user in FPS (first person shooter) camera mode. Users can move through the virtual environment using the W,A,S,D or arrow keys on their keyboards, and input information by moving and clicking their mouse. They can watch videos, explore a 3D environment and play interactive games directly in their web-browser. Each participant's progress and participation are recorded to a database that can be accessed by the mentor.

Why was the 3D TALETE CLE selected?

Interactive simulation /IS/ is a flexible learning tool providing environment which supports constructivist learning. The structure supports spontaneous and intuitive selection of the right strategy for series of actions. Simulations prove how useful is the information about objects, events or phenomena (which are difficult to be verbalized) and the conditions for their appearance. Students can use different strategies of action. They can construct hypotheses and follow causal and consequential relations among the events and processes. The students have more initiative and control over the procedure. The feedback in simulation is indirect visual feedback. In all interactions with a system the students can observe the consequences of their own actions and reconstruct or entirely change their hypotheses. Why simulations and immersive worlds would be useful for learning?

1. Wide uptake of virtual worlds among young people. The lines between virtual worlds, games and social networking are blurring. “Over next 5 years the majority of young people under 18 will be using these kind of applications daily and therefore have different expectations about how education may be delivered to them”[3].

2. Recent work in the gaming area has demonstrated how whole brain activity occurs when learners are playing games as opposed to limited brain activity when learners are learning in formal ways. This supports constructivist approaches to learning [3].

3. The powerful nature of learning-by-doing is maximized in simulation and game based learning. Users can learn from doing through playing and enacting situations, problems and challenges... Learning in this context is enriched through the activities and interactions.

4. Perhaps rather than being concerned simply with effectiveness and efficiency, contemporary approaches to learning might also embrace engagement, enjoyment and transformation as part of everyday experience [11].

Shaffer's (2006) book: *How Computer Games Help Children Learn* is fundamentally a book about epistemology [8]. What computers do, Shaffer argues, is to let us work with simulations of the world around us. They let us make models that work like some part of the simulated world, making it possible to experiment with reality and create imaginary worlds where it is possible to do what we otherwise could not do at all, in a safe environment. By letting users play with powerful simulations computers change what it means to know and do something. The point of Serious (Epistemic) games is thus that instead of learning facts, information and theories to apply them to something later on, facts, information and theories are learned and remembered because they are needed to complete a task or solve a problem in the first place.

3D TALETE CLE was tested in all partner countries involved in the project by more than 100 teachers and 500 students. All participants in the testing phase demonstrated high satisfaction level. The survey results show that the proposed didactic module and methodology are efficient, the products are useful and with high level for transferability in other subject domains. The evaluation report published in the public part of the project website depicts the main directions and aspects for future work and research.

Taking this into account it was considered as reasonable to deliver the 3D TALETE CLE to the participants in the course in order they to gain practical experience in using serious games in Maths training and learning.

Learning content organization

The course content was structured in the following topics:

- Methods and instruments for evaluation of educational systems. Procedures and stages of the monitoring and evaluation.
- PISA philosophy and the mathematization concept as a mental process which produces Maths [1].
- Contextualization as a process in which mathematical ideas are embedded in everyday contexts. The contexts support the learning of mathematical ideas [5].
- Presentation and explanation of the functionality and tools of the 3DTALETE CLE.
- Presentation of the assessment scenarios embedded into the 3D – stages, recommendations, evaluation schema, etc.

Learning content topics were selected in order to be improved the quality and efficiency of Maths training in the terms of:

- Improving the quality of learning in order to support the development of students' basic and transversal competences (mathematics literacy, learning to learn, social and digital skills);
- Improving attractiveness and efficiency of ISCED (International Standard Classification of Education) levels 2 and 3 of education and training (nearly the end of compulsory education) through the 3D virtual world;
- Supporting high quality teaching and teacher training;
- Constructivist learning and technology enhanced learning environments
- Establishing the balance between methodology and technology in order to make the technology an added value.
- Supporting teachers in developing new digital competences and learning new teaching methods.
- Consolidation of the pedagogical and computer skills of the teachers.

Conclusion

This course was one of the first that reached the necessary amount of people willing to participate in BFU distance education. Approximately 85% of the subscribed trainees finished successfully the theoretical and practical training. 7% of the teachers were not able to participate because of some technical problems. Again there is interest in this course by the audience of teachers.

Taking into account the above our research team intends to develop an environment for teachers and students, where they will benefit with enhanced and much more attractive pedagogical tools in order to improve the teaching and learning of Maths and science through the use of 3D Serious Games. The pupils' motivation in the study of Maths and science will be stimulated and reinforced through the discovery of the challenging connections between Maths and Science with the arts, such as art, music, etc., letting them understand the usefulness and their application in everyday life. The students will discover how mathematical and scientific rules and formulas affect all the spheres of reality, in particular that of the arts, like for example the perspective in painting, the harmonic series in music, the physics principles in dancing and so on. Moreover the use of the 3D serious games will support the teaching of teachers and the study of pupils in the improvement of their digital skills enhancing the interconnections among different realities and more learning levels. The innovative aspects of the work in this direction could be summarized as follows:

- More attractiveness of the pedagogical tools through the discovery of “challenging connections” between Maths/Science and the artistic cultural heritage.
- A blended methodology based on a mix of formal and non-formal education with the organisation of one travelling training face-to-face sessions.

These “challenging connections” become a challenge to the culture of national teaching proposing a mix of formal and non-formal education. The aim is to point up how Maths and science are present (although not so evident) and detectable in each human experience, even in the artistic and creative expressions.

Bibliography :

- [1] Blum W., Borromeo-Ferri R. (2007), Mathematical modelling: Can it be taught and learnt?; presented during the event „*The future of Mathematics Education in Europe*“, 17 Dec 2007, Lisbon, Portugal.
- [2] International Association for the Evaluation of Educational Achievement (IEA), *Annual Report*, <http://www.iea.nl/>
- [3] Kato P. M., Cole Steve W., Bradlyn A. S., Pollock B. H. (2008), *A video game improves behavioural outcomes in adolescents and young adults with cancer: a randomized trial*. *Pediatrics*, 2008, 122(2), pp. 305-317.
- [4] Monova-Zheleva M., Zhelev Y., Implementation of the Explorative Learning and Learning-by-doing in Geometry, Proceedings of the Forty Second Spring Conference of the Union of Bulgarian Mathematicians, Borovetz, April 2–6, 2013, pp. 101-106
- [5] Nelissen J., Tomic W., *Learning and thought process in realistic mathematics instruction, in Curriculum and teaching*, 1993, Volume 8, No 1, edited by James Nicholas Publishers.
- [6] Organisation for Economic Co-operation and Development (OECD), *Pisa 2006 science competencies for tomorrow's world*, 2007, Vol. 1 – analysis. Paris: OECD.
- [7] Organisation for Economic Co-operation and Development (OECD), *Pisa 2006 - Data*, 2007, Vol. 2: Data. Paris: OECD.
- [8] Shaffer, David Williamson, *How Computer Games Help Children Learn*, Palgrave MacMillan, 2006.
- [9] TALETE Project website <http://taleteproject.eu>
- [10] TIMSS <http://nces.ed.gov/timss/educators.asp>
- [11] Wilson B., Parrish P., Veletsianos G., *Raising the bar for instructional outcomes: Towards transformative learning experiences*, *Educational Technology*, 2008, 48(3), pp. 39-44.
- [12] Университетски център за дистанционно обучение, Оперативна програма „Развитие на човешките ресурси” 2007-2013 на МОН, Схема BG051PO001-4.3.04 „Развитие на електронни форми на дистанционно обучение в системата на висшето образование”, уебсайт <http://ucdo.bfu.bg/>