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INNOVATIVE METHODS AND APPROACHES FOR IMPLEMENTATION OF THE EXPLORATIVE LEARNING AND LEARNING-BY-DOING IN GEOMETRY*

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This article presents some results and outcomes developed in the framework of the project "Teaching maths trough innovative learning approach and contents" (TALETE) [1]. Main aim of the project is to improve the training and learning of Math (especially Geometry) by development of modern pedagogical instruments and methodologies based on the advanced ICT achievements. The article presents briefly the project as a whole. Next section describes the main standards and paradigms used as fundaments of the development in methodological and technological aspects. The main functionalities of the developed e-learning platform and 3D virtual world are also briefly presented. These platforms are necessary for the implementation of hybrid training and learning in the class room in order to achieve balanced integration of the theory in accordance with the concepts of PISA about mathematical literacy and competency clusters.

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.

Definitions of intended outcomes are needed for steering educational processes that result in OTL, which in turn are supposed to influence the competencies and attitudes of students. Moreover these definitions are needed to be able to construct assessment schedules for measuring the extent to which the intentions are realized.

Intentions may be formally legislated in syllabi, examination standards or "Intended Curricula"**. 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. An 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) [2,3] and IEA TIMSS (Trends in International Mathematics and Science Study) [4,5]. These assessments are intended to assist policy makers to better understand to what extent their educational systems are measuring up with developments taking place in other countries.

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Key words: PISA, Mathematical Literacy, Mathematization cycle, Learning objects, 3D CLE, Serious Games.

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The data gathered in the TIMSS project related to the intended curriculum (the curriculum specified by the system or other body), the implemented curriculum (the curriculum as taught by teachers, the nature of actual classrooms), and the attained curriculum (what students have learned).

The PISA project is not directly focused on any of these aspects of curricula. Rather PISA is concerned with how well 15 year old students can make use of science knowledge acquired from school and from other sources, in situations in everyday life that involve science and technology.

The worldwide surveys report that EU students often lack mathematical competence and key basic competences in science and technology.

TALETE outcomes and products, addressed to the teachers and their students, aims to test an innovative pedagogical tool making the study of Mathematics more interesting and creative, transforming a possibly difficult situation into a simpler, more dynamic, flexible, surprising, engaging, intriguing one to foster the student's curiosity. Through the TALETE training path the 14-16 years-old students will improve their deep mathematical understanding with a focus on the geometry, especially their performances on the base of OCSE PISA, IEA TIMSS and national evaluation schedules.

Main target groups of the project are:

- Teachers – They will develop and test innovative didactic tools that can help raise the interest level and motivate students to acquire mathematical skills;
- Students – They will test directly with their teachers the attractiveness and efficiency of new didactic tools and will also develop transversal skills (e.g. communicative, learning to learn, social and digital skills) useful for future professional development.

In the implementation of the aims and objectives described above are engaged the following institutions and countries: Universita' Degli Studi "Guglielmo Marconi" – Italy; University of Thessaly – Greece; Kadikoy Ilce Mille Egitim Mudurlugu – Turkey; Ial Lazio Srl Impresa Sociale – Italy; Burgas Free University – Bulgaria; Rezzable Production Ltd – United Kingdom.

Methodological fundaments. The concepts of the mathematization and mathematical literacy defined by PISA are main theoretical fundaments for the TALETE methodology development. PISA put the emphasis on mathematical literacy and "preparation for life". The starting point for the testing is quite different to TIMSS. After consideration by the science expert group, the following definition of mathematical literacy was adopted by PISA for its testing: "Mathematical literacy is an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgments and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen." This definition includes mathematical thinking and use of mathematical concepts, procedures, facts and tools for describing, explaining and statement of hypotheses about processes and phenomena. In other words, in mathematics PISA assesses students' skills to formulate, use and interpret mathematical problems in a variety of situations. Figure 1 represents the mathematical literacy elements and overall mathematization cycle according PISA. The mathematization involves moving from the everyday to the mathematical: it describes real-world context expressed mathematically. The contextualization involves moving from the mathematical to the everyday: it describes mathematical content ex-

pressed in everyday language. Which is their role in the planning of math lessons? Can the mathematical ideas be embedded in everyday contexts?

The educational model of TALETE project starts from the concept of the mathematization: it describes real-world context expressed mathematically. The mathematization uses everyday contexts expressed in mathematical language and concepts for solving real problems and the mathematics becomes the vehicle for this purpose [6]. The mathematization is a mental process which produces mathematics: you see the world perceiving relationships, properties and structures. The teacher constructs situations in which the learner can mathematize: perceiving the chains of necessary deductions. The contextualization is a process in which mathematical ideas are embedded in everyday contexts. The contexts support the learning of mathematical ideas [7]. Often in the school textbooks, you find artificial problems, while if the teachers use the contextualization and mathematisation, they can offer to students more attractive mathematical problems and realistic issues. For example, plan the lesson students in primary school about the proportions. How can the teacher mathematize the process of drawing a face? The students can take measurements in real contexts of the position of various facial features. Using the rules they can measure and calculate the positions and size for the eyes, ears, and calculated the proportions. They can look at the overall shape of faces and noting the variation from a circle or ellipse. It's important that the pedagogical context must be made explicit to enable pupils to understand the purpose and make sense of the mathematics. The context is a situation that is familiar to a student. For example, how many cups of water go into a glass of water? The mathematization is viewed as a constructive, interactive and reflective activity. To begin, the point of departure for education is not learning rules and formulas, but rather working with context. A context is a situation which appeals to children and which they can recognize in theory. The mathematization of the nature has to be enriched with the dense spectrum of various mathematical practices. It means that math can be teach and learned in active and creative process. On the basis of the concepts and principles described above and in accordance with the standards set by TIMSS, PISA and National Curriculums of Math the project Research Educational Team (RET) selected relevant assessment schedules on national and international level in the domain of teaching and learning Math (especially Geometry) for 14-16 years old

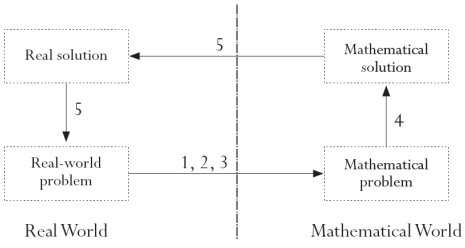

Fig. 1. Mathematization process according PISA

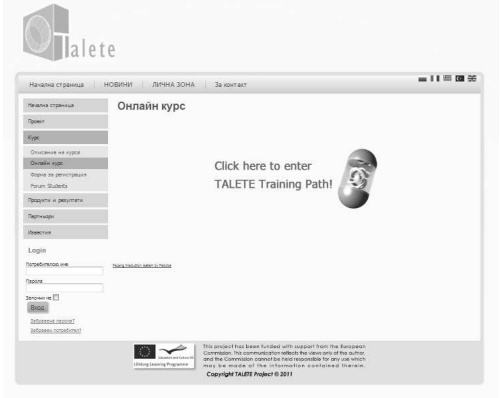

Fig. 2. TALETE e-Learning platform Screen

students in the partner countries. These schedules were developed as 3D serious games scenarios implemented in a virtual environment. Under the project framework was developed training course for teachers of Math in order to make them familiar with the v-learning principles and to improve their theoretical and practical preparation for using virtual worlds in the classroom activities. After finishing the course the involved teachers tested the innovative methodology and pedagogical instruments with their students who were separated in experimental and control groups.

Hybrid learning environment TALETE. The TALETE training path design is divided into two sections related to the learning and training environment and according to the target group considered: E-learning platform for the teachers and 3D environment for teachers and students.

TALETE e-Learning Platform. The e-learning platform contains educational pills (translated into English, Italian, Greek, Bulgarian and Turkish) and a forum addressed only to the teachers, and the 3D virtual environment contains the scenarios produced on the base of the assessment schedules previously selected by Research and Education Team.

This last environment is addressed to the teacher who will test the effectiveness of new pedagogical tools with their students. The e-learning platform is realized in order to deliver the e-course, in terms of educational pills and web seminars, and the social area for the teachers. This tool allows target group to access to their training contents according to the defined the TALETE training path.

The TALETE e-learning platform is developed on the basis of open source platform Claroline (please see Figure 2). The learning content is developed in form of the SCORM learning objects. The "Learning objects" are defined as small, independent chunks of knowledge or interactions stored in a database, which can be presented as units of instruction or information. They are typically self-contained, interactive, and reusable.

The following learning objects will be available in the TALETE e-platform: The Multimedia Lesson; Slides and Lecture notes. The Multimedia Lesson is a learning object delivered through the e-learning platform built up by an audio explanation synchronised with a slide presentation using the Adobe Presenter plug in. The interface of each Multimedia Lesson is provided with a hypertextual index allowing the user to navigate the lesson, to interrupt and start again the listening without returning at the beginning of the explanation. The Slides realised by the didactic experts for their audio lessons have been converted into .pdf. Slides are printable documents allowing the users to take note while listening to the explanation. Thanks to the Slides the user will write didactic expert's comments or memo and reminders. They will be useful to brush up the lesson in off-line modality. The Lecture Notes represent in depth studies to better detail one of the contents dealt with during the audio lesson or to provide students with a different perspective of the contents already explained.

TALETE 3D Virtual Environment. The 3D virtual Constructivist Learning Environment (CLE) contains the scenarios produced on the base of the assessment schedules previously selected by RET (Research and Educational Team). TALETE CLE is addressed to the teachers who will:

– test the effectiveness of new pedagogical tools with their students;
– evaluate the student performance for the achievement of the final pedagogical goal.

The main objective of the TALETE educational game is to improve learning skills and

overall understanding of the math course material. Here appropriately developed game can introduce an amount of wit and levity to balance the intensity of the experience and to make a big improvement. 3D environment helps teachers to:

- Get Attention – which aids students in shifting from one task to another and increases focus. However, this won't last very long and you need to be able to pull them into something with a longer burn time;
- Maintain interest – you will want to move them into content that stimulates them and continues to intrigue them. This can be a combination of short interactions and longer challenges;
- Achievement – collecting some points and earning some badges adds a sense of purpose and supports focus on key elements. Students are also very goal oriented and will want to make sure their time is taking them somewhere;
- Increase Openness to New Ideas – when people are enjoying something, they can be a lot more receptive to new concepts. If collecting information is exciting people will get into the details fast and with greater retention.

Students will login to the TALETE website to access the 3D virtual environment. An animated, 3D scenario plays at the opening of the game to introduce the overall storyline. The students will then arrive in a virtual kitchen (everyday context where math ideas have been embedded) to unlock the challenges set forth by the TALETE partners. The virtual world has been developed on the basis of the software platform Unity 3D for creating of serious games and virtual worlds and is addressed to the teachers and students from secondary schools in Europe. The challenges are specific mathematical problems covered by the topics of the National Curriculums of the partner countries. The problems have been implemented as separate, but linked in a common scenario, mini-games. Clicking on selected objects throughout the kitchen will unlock interactive exercises and hidden surprises (also known as "Easter eggs"). All eight mini-games (challenges) can be accessed by student username and password. The all nine 9 clickable points are as follows: Cookbook (Introduction); Towel (Rotating Triangles – Turkey); Floor Tile (Roman Mosaic – Italy); Blueprints (Swimming Pools – Bulgaria); Ironing Board (Thales Theorem – Greece); Chalkboard (Calendar Pages – Turkey); Cakes (Cakes and Boxes- Bulgaria); Window (Garden Wall – Italy); Computer (Similar Triangles – Greece).

The kitchen is a fully explorable 3D space, viewed by the user in FPS (first person shooter) camera mode. Users will 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.

Students can watch videos, explore a 3D environment and play interactive games directly in their web-browser.

Students may explore the kitchen independently or with the guidance of a teacher as part of a lesson plan. Each student's scores will be recorded to a database that can be accessed by the teachers to evaluate performance.

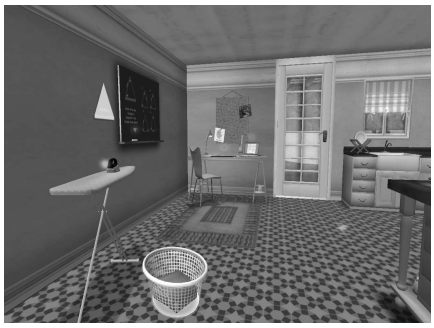

Fig. 3. TALETE 3D Virtual CLE Screen

Conclusions. The use of a 3D environment and interactive games will challenge and engage students on multiple levels and add incentive to achieve goals and improve testing scores. Each assessment schedule is mini-game explained in detail in the next educational pills.This technology will allow students to explore and make discoveries within a virtual space, watch animations that will illustrate mathematical equations, interact with 3D mathematical concepts and make choices based on accumulated information.

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ИНОВАТИВНИ МЕТОДИ И ПОДХОДИ ЗА ОСЪЩЕСТВЯВАНЕ НА ОБУЧЕНИЕ ПО ГЕОМЕТРИЯ ЧРЕЗ ИЗСЛЕДВАНЕ И ПРАКТИКА

Мария Христова Монова-Желева, Янислав Панайотов Желев

В настоящото научно съобщение са представени резултати и продукти, разработени по международен проект "Teaching maths trough innovative learning approach and contents" (TALETE) [1]. Основната цел на проекта е да се усъвършенстват преподаването и изучаването на математическите дисциплини (по-специално на геометрията) чрез предоставяне на модерни педагогически инструменти и методологии, базирани на приложението на съвременните информационни и комуникационни технологии. Изложението накратко представя проекта като цяло. Описани са основните стандарти и парадигми, послужили като фундамент на разработката в методически и технологичен аспект. Представени са разработените по проекта платформа за е-обучение и 3D виртуален свят, необходими за осъществяването на хибридно обучение в класната стая, даващо възможност за балансирано интегриране на теория и практика в контекста на учебното съдържание по геометрия за учениците на възраст 14–16 години и съгласно концепциите на PISA за математическа грамотност и дефинираните от програмата клъстери на компетентностите.