TOWARDS IMPROVING MATH UNDERSTANDING USING DIGITAL ART LIBRARY AS A SOURCE OF KNOWLEDGE

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Abstract

Teaching Math and Geometry in particular follows a standard methodology of the Science education. Its main teaching problems are related to difficulties or misunderstanding of the learned content, its abstractedness, not enough real-life examples, and, as a result, low attractiveness. Geometry topics are presented using pure mathematical tasks, assuming that students know how to solve them. In general, this conclusion can be considered as inaccurate, not because students cannot solve the tasks, given to them, but because they do not distinguish the steps that lead from the "given" to "searched" and as a whole, they do not associate the solution with the real world. The incomprehension of the solution effect is often the main reason.

In this context, on the base of the high performance achieved by Asian Students as provided by the Organisation for Economic Cooperation and Development (OECD) international survey, this paper discusses a solution aiming to improve the Math understanding using Art. The proposed method makes a combination of the European and Asian (Singapore's method) learning and teaching math approaches, and exploits the innovative potentialities gained from the integration of digital art management systems and science. We use the digital art libraries as sources for demonstrations of geometry knowledge. These systems present a wide range of real-life examples and show how the great artists creatively use the geometrical forms and objects to present more realistic human anatomy and architecture. This helps students revive the art perception displaying its hidden science base and understand that creators' reasoning is reducible to mathematical concepts.

Keywords: Mathematics education, learning by doing, problem solving, inquiry-based learning, arts, technology-enhanced learning.

1 INTRODUCTION

Teaching math and geometry follows still traditional methods which were predominant approaches, mainly, in the United States in the early-to-mid 20th century [1]. In general, these are methods based on direct instruction given students by teachers in order to perform specific tasks. As a result the tasks are taught in isolation rather than as a part of whole and teachers spend most of their time to explain and ask questions, while their students are obliged to listen and copy down notes.

The teaching traditional process is focused more on contents mastery than on abilities development and problem solving skills. This determines a misunderstanding of the learned concept because focused more on the theoretical part and less on the application of the concepts. Mathematics study becomes, for students, something of too abstract, far from real-life-examples determining its low attractiveness [2].

For example, geometry subjects, often, are presented through mathematical tasks, assuming that students know how to solve them. However, the inaccuracy of this statement is demonstrated by the fact that students can't associate the solution with real life problem, because they can't distinguish the steps that lead from the "given" to "searched". The consequence is that they don't know how to solve the problem given by the teacher.

Therefore, more innovative teaching and learning approaches are needed to improve not only student performances but also the development of those transversal skills, such as problem solving and creativity, which are useful for their future professional life.

2 A COMBINED APPROACH USING ART AND TECHNOLOGY

In this context, analyzing the high performance achieved by Asian Students in the Organisation for Economic Cooperation and Development (OECD) international survey, a possible solution is given, at

pedagogical and methodological level. It foresees a combination between the European and Asian (Singapore's method) learning and teaching math approaches using the Art and the technology through arts' demonstrations delivered through digital cultural ecosystems.

The proposed approach consists in the introduction of mathematical concepts through three phases process: concrete, pictorial and abstract as is used in the Singapore's method for mathematics study. This means using a symbolic representation to ensure that the concrete mathematical experience allow students to reach an abstract representation [3].

The main objective is to favor a relational reasoning connected to a concrete mathematical concept and to develop skills for the recognition of relationships among variables, to be able to work on them dynamically. The method approach, thanks to the teacher mediation and facilitation, can reinforce in the student the recognition of the relationship between syntax and semantics, for example, of arithmetic writing [2].

The introduction of the arts-works through the three phases of the Singapore's method, supports students in their reasoning process where applicable knowledge, imagination, creativity and problem solving skills combine together thanks to the use of the "variations" in mathematical problems. In other words, even if the mathematics formula/concept to be studied remains constant, the background/the context or, in this case, the art-work referring to them, will change. This will allow students to learn in depth the mathematics concepts up to reach their abstract representation.

Moreover, this learning process results being reinforced and more effective by using the technology through the integration of some digital tools in a virtual environment, such as a 3D Virtual Museum [4].

2.1 The Use of Digital Art Library for Demonstrations of Geometry Knowledge

Libraries have always been a valuable source of knowledge resources. Their contemporary technological equivalent - digital libraries also pretend to hold this highly-valued position mainly due to the variety of content resources and the provisioning of easy access to them. A digital library is not just a static digital content repository, but also a system with a dynamic federation of functional units satisfying a wide variety of users' content requests [5] [6]. This flexibility came as a result of the needs of the market, the emergence of new technologies, and especially from the request for stricter use of the existing resources and adapting DLs content and services to the needs of different user groups [7].

Being desirable sources of knowledge, DLs can become an alternative of the contemporary learning management systems, which currently follow strictly defined learning procedures and rarely include creativity, freedom of thinking, and emergence / instigating of new ideas and inspirations. They can provide some non-trivial, but creative learning tasks, for example [7]:

- Observe, analyze and study the target domains: find or verify trend/s in the domain, find new trend/s, influence, and problem/s, reach new result/s.
- Make new developments and projects for shared and (or) linked digital assets (DAs); new learning projects, documentaries, performance.
- Content-dependent exploitation of DAs for different purposes, incl. interactive virtual exhibition, gaming and gamification, storytelling, mobile applications, study, *etc.*
- Stimulate new research and promotion of innovative usage and user interaction with the target DL domain, including Maths, *etc.*

In the current research project, dedicated to math and art convergence, we used a small private digital art library, keeping digitalized Thracian architectural objects, for demonstrations of geometry objects and knowledge. The Thracian architectural collections in it are kept by prof. Malvina Rousseva during her long-live research of the Thracian cult architecture.

A formal cognitive scenario may include some or all of the following steps:

1 The teacher makes a selection of digital artefacts from a digital art library. The objects contains hidden geometry objects, which will be observed during a current learning topic.

2 During the introductory part of the lesson, the teacher asks the student to find the hidden geometry objects and to specify their types.

3 The teacher presents some properties and dependencies of the observed geometry objects using mainly the digital art objects.

4 Through the mediation of teacher, students develop research skills in order to find other art-works already existing based on mathematics concept studied. The teacher gives learning tasks to the students: 1) to find in the digital art library artefacts, keeping the observed geometry objects; 2) to count figures' face, circumference, volume, *etc.*

5 The teacher supports students in the use modeling programs for the similar objects creation and manipulation to reinforce geometry understanding and to explore relations between arts and math.

6 At the end of the teaching step, the teacher facilitates the development and creation process in students through the usage of 3D digital tools representing their own art-works based the mathematical formula/concepts studied and, then, to upload them in an special virtual museum, realized with Unity 3D.

3 DIGITALIZED THRACIAN ARCHITECTURE DEPICTING GEOMETRY FIGURES AND KNOWLEDGE

The circle, the square, the cube, and the sphere, which are main figures in the geometry, are the basic elements of the Thracian cult building [8]. In fact, these buildings present round and square rooms, cubic and spherical spaces, columns, semi-columns of a certain number, height and shape Each of them is a result of a thoughtful and realized conceptual design. Several examples are depicted on the following figures. Figure 1 shows the central chamber of the cult building under Ginina Mogila, Sveshrari village. Figure 2 depicts Shushmanetz Mogila (the valley of the Thracian kings near Kazanluk village) and spheres inscribed into the plan of the building in it.

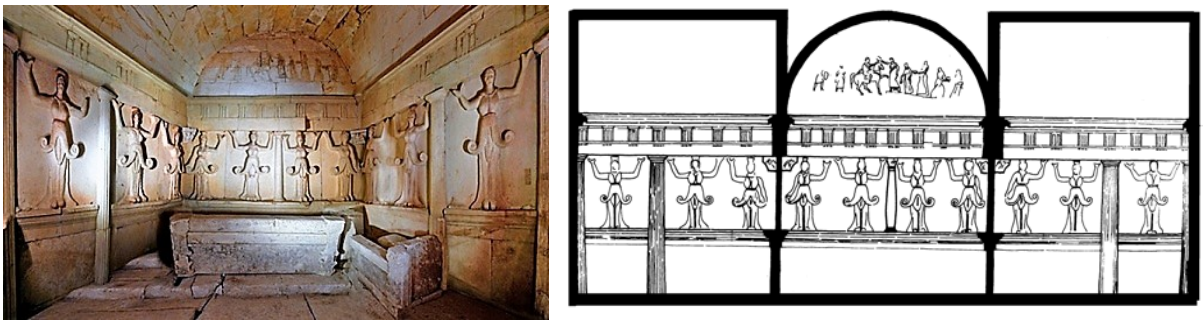
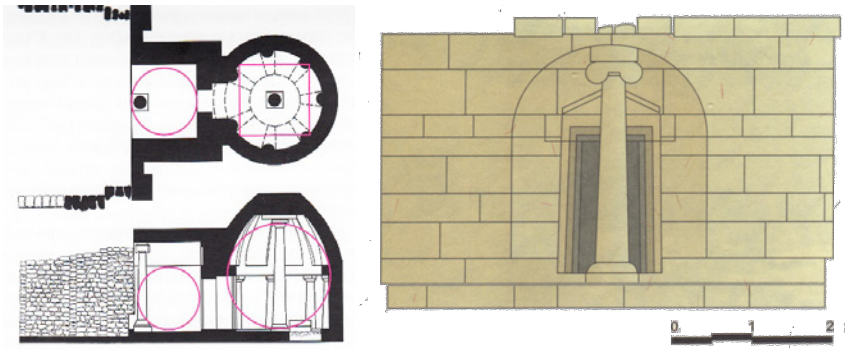


Figure 1. Central chamber of the cult building under Ginina Mogila, Sveshrari village

(a) (b)



(c)

Figure 2. Shushmanetz Mogila antechamber (a) and central chamber (b); Overall plan of the cult building (c)

Figure 3. Ceilings in Thracian cult buildings

The Thracian also built mainly three types of doorway frames (trapezoidal, stepped and arched, figure 4) and several types of false (corbel) vaults and beehive vaults.

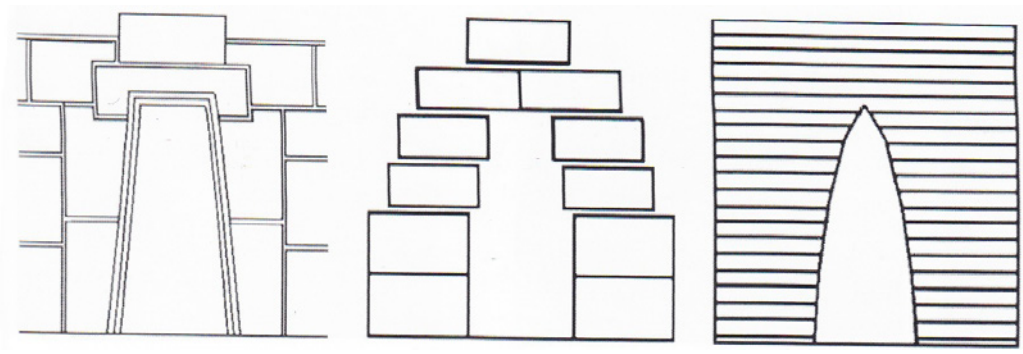


Figure 4. Doorway frames in Thracian cult buildings

Thracian architectural objects can be used for demonstrations of geometry figures and their properties under several learning topics, such as: Circle, Square, Cube, Sphere, Trapezoid, described and inscribed figures, symmetry, graphs, *etc.*

Another example [9] comes from another form of the arts as the “labyrinth”, which is the motif related to a coin found in the Minos palace in Knossos. Its object can be used to study rectangles, squares, lines, rotation and angles (see Figure 5).

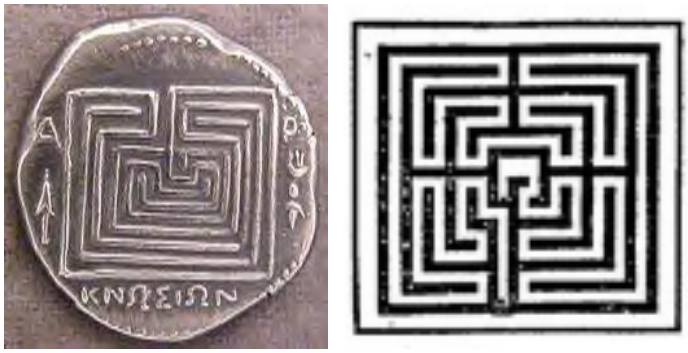


Figure 5. Cretan labyrinth on silver coin from the Minos Palace in Knossos and its digital re-construction.

4 CONCLUSIONS

The model proposed help students make experience different types of representations of the same concept by finding correspondences and relationships among them. This step conducts students to consolidate conceptual understanding. Thanks to this transition, starting from concrete objects to pictures arriving then to symbols, the Singapore approach offers many and various opportunities to learn maths concepts, especially for students with difficulties.

In addition, it facilitates the access to the digital resources, bringing cultural content to new audiences in novel ways. Using them as sources for demonstrations of geometry knowledge will give a real context and will show how the great artists creatively use the geometrical forms and objects to present more realistic human anatomy and architecture. In this context students will revive the art displaying its hidden science base and mathematical thinking of their creators.

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REFERENCES

[1] S.L. Lightner, “A Comparison of the Effectiveness of Applied and Traditional Mathematics Curriculum,” *Journal of Industrial Technology*, 15(2), pp. 2099-2102, 1999.

[2] M. Tramonti, “Mathematics Education reinforced through innovative learning processes,” *EDULEARN17 Proceedings*, pp. 9279-9284, 2017.

[3] B.S. Witzel, P.J. Riccomini, E. Schneider, “Implementing CRA with secondary students with learning disabilities in mathematics” *Intervention in School and Clinic*, 43(5), pp. 270-276, 2008.

[4] M. Tramonti, “Reinforcing Learning Setting through the Use of Digital Tools”, *DiPP2017 Conference Proceedings 7th Edition*, Sofia, Bulgaria, pp. 159-167, 2017.

[5] D. Paneva-Marinova, R. Pavlov, N. Kotuzov, “Approach for Analysis and Improved Usage of Digital Cultural Assets for Learning Purposes”, International *journal “Cybernetics and Information Technologies”*, vol. 17, no. 3, pp. 140-151, 2017.

[6] D. Paneva-Marinova, L. Pavlova-Draganova, L. Draganov, V. Georgiev, “Ontological Presentation of Analysis Method for Technology-enhanced Learning,” *Proceedings of the International Conference on Computer Systems and Technologies ComSysTech’12*, Ruse, Bulgaria, pp. 384-390, 2012.

[7] D. Paneva-Marinova, M. Goynov, D. Luchev, Multimedia digital library: Constructive block in ecosystems for digital cultural assets. Basic functionality and services. Saarbrücken, Germany: LAP LAMBERT Academic Publishing, 2017.

[8] M. Ruseva, Methodology for the Scholarly Investigation of Thracian Architecture. Analysis Interpretation Symbolism, Sofia, Bulgaria: Institute of Art Studies, 2013.

[9] K. Fenyvesi, I.O. Téglasi, I. Prokajné Szilagyi, Visuality & Mathematics – Experiential education of mathematics through visual arts, sciences and playful activities. Eger, Hungary: Eszterhazy Karoly College, 2014.