Challenging multiple perspectives within e-learning contexts: a scenario-based approach for the design of learning activities

M. Kordaki[*1]

[1] Department of Computer Engineering and Informatics, Patras University, 26500, Rion, Patras, Greece

This paper presents a scenario-based approach for the design of learning activities within the context of e-learning. This approach sits well within the context of social and constructivist theories of learning [1-4] which stress holistic approaches to the subject matter. In fact, a scenario is a framework that encourages learners to develop Multiple Perspectives (MP) on the concepts in focus. The design of scenario-based activities emerges as a result of answering three essential questions; namely: a) what has to be learned, who the learner is and how the learning process is taking place. To address the first question, designers need to create a network of concepts related to the concepts in focus, in order to provide learners with opportunities to develop MP on these concepts. To this end, the role of e-learning environments that provide various tools is crucial, as they can scaffold learners to develop multiple solutions for the tasks at hand, using the various tools provided, while at the same time using different concepts. To address the second question, designers have to define the main learner difficulties regarding the previously-mentioned network of concepts. They then have to find ways to provide learners with opportunities to express and to overcome these difficulties, taking advantage of the tools provided. Finally, to address the third question, designers have to take into account basic aspects of the previously mentioned learning theories, while at the same finding ways to exploit the nature of tools of the e-learning environment that is provided to learners for interaction. The proposed approach is analytically presented through a specific example for studying the concepts related to the mid points of a triangle within the context of tools of the well-known educational software Cabri-Geometry II [5].

Keywords e-learning; Dynamic Geometry Sustems; mid points of a triangle, constructivism, learning activities

1. Introduction

A fundamental aspect of intelligence is the habit of considering one's reality from MP, representing the perceived reality, and working to reconcile the various perspectives [6]. Furthermore, in a diverse society, not only is such habit one of intellectual strength, but also one of social strength. The fundamental attitude inclining one to habitually consider and integrate a variety of viewpoints deepens his/her understanding, is an appreciating skill within the business world and also promotes the corresponding life disposition to embrace human diversity. Many instructional approaches also suggest learning using MP, such as the Cognitive Apprenticeship approach, where reflections about the contents using MP are proposed [7], the cognitive flexibility approach [8-9], where the method of landscape criss-crossing is suggested, that is, learning a new domain by exploring it from various perspectives, and other multiple approaches.

Many mathematics educators have also argued in favour of considering MP in the learning of mathematical concepts. For instance, Freudenthal [10] considers the different ways in which a topic might be used and how those different perspectives lead to different understandings. By considering MP in mathematics, the learner also has the opportunity to make use of Multiple Representation Systems (MRS) [11, 12]. Among the main advantages of MR are that they [11, 12, 14]: (a) allow learners to combine representations containing complementary information; thereby, the complexity of every single representation can be limited; (b) can constrain the interpretation of single representations, thereby helping to avoid misinterpretations; (c) through being connected, can be useful for gaining a deeper understanding of the learning materials, because complex interdependencies can be interpreted in new ways, and abstraction as well as generalisation can also be fostered (d) allow learners to express the diverse kind of knowledge they possess while at the same time expressing their inter- and intra-individual learning variety, and (e) can help learners to develop a broad view of the concepts in focus.

Emphasizing the consideration of MP on the concepts in focus provides opportunities for the expression of learners' multiple intellingences [15]. In the development of MP, the acquisition of conceptual knowledge is essential. Emphasis is also placed on the development of holistic curricula such as those stressing inter- and

[*] Corresponding author: e-mail: kordaki@cti.gr, Phone: +30 2610-993102

intra-disciplinary approaches. At this point, it is worth noting that traditional learning theories [16] emphasize the isolation of the concepts to be learned and the promotion of drill and practice activities. Contrary to these theories, modern social and constructivist approaches to knowledge construction emphasize the performance of meaningful learning activities taking into account holistic approaches to the subject matter in question [1-4]. Within the context of these modern approaches, the central and active role of learners in their learning is crucial. Learning environments that support exploratory, investigative and MP-based learning facilitate learners to be motivated, active and open minded. In the formation of such environments, the role of technology is essential.

In fact, technology has become an essential tool for the learning of all learning subjects in today's world and can be used in a variety of ways to improve and enhance the learning of mathematics. As NCTM [17] highlights in its standards, technology can facilitate mathematical problem solving, communication, reasoning and proof; moreover, technology can provide students with opportunities to explore different representations of mathematical ideas and provide them with support in making connections both within and outside of mathematics [18]. Among the educational software dedicated for the learning of mathematical concepts, Dynamic Geometry Systems - and especially Cabri-Geometry II [5] - play a central role. In fact, Cabri provides learners with multiple tools for the learning of a diversity of concepts of Eucledian Geometry. Learners can use these tools to develop intra-disciplinary approaches to the concepts in focus. Specifically, learners can link the concepts in focus with other concepts within the same discipline and form relationships among them. In this way, learners can form MP on these concepts and view these in integration. Cabri also provides possibilities for Multiple and Linked RS of the same concept, at the same time encouraging MP of it. Furthermore, Cabri offers possibilities for dynamic manipulation of the geometrical constructions formed using its tools. That means, when learners directly drag these constructions, they can alter their form while at the same time conserve their basic properties. In the context of such manipulations, learners can explore multiple visual representations of these constructions and can form hypotheses and conjectures about their geometrical properties and the underlined concepts. To this end, there is also the possibility of collecting large amounts of numerical data which can be used by students to form and verify conjectures concerning the geometrical concepts in focus. Moreover, Cabri is a highly interactive environment that also provides learners with multiple types of both information and feedback to facilitate the formation and verification of conjectures as well as the self-correction of their constructions. Finally, the history of student actions is captured and possibilities for the extension of the environment are also available to teachers and learners through the addition of specific macros on the Cabri-interface. These macros can support the performance of multiple learning activities seen as crucial for the development of integrated intra-disciplinary approaches to the concepts in focus.

Taking into account all the above, in the next section of this paper we propose a specific design methodology, called "scenario-based' methodology, for the design of learning activities that can enhance MP of the concepts in focus within the context of e-learning. This approach sits well within the context of social and constructivist theories of learning [1-4] which stress holistic intra-disciplinary approaches to the subject matter. Such a methodology has not yet been reported. As a result of this methodology, an architecture of the proposed learning activities was formed, and this is also presented below. The proposed methodology and architecture are presented through a specific example demonstrating the whole design process and the formation of a scenario-based activity for studying the mid points of a triangle by secondary level education students using the tools of Cabri Geometry II. Potential dimensions of the said design methodology are also discussed and, subsequently, there follows a summary, with future research plans also being considered.

2. Design methodology and architecture of the scenario-based activities in the context of e-learning

The design of scenario-based activities emerges as a result of answering three essential questions, namely: a) what has to be learned, b) who the learner is and c) how the learning process takes place. Towards answering the first question, it was considered essential to create a model of the subject matter, consisting of a network of essential concepts related to the concepts in focus, in order to provide learners with opportunities to develop MP on these concepts as well as to view all of them in integration. To this end, the role of e-learning environments that provide various tools is crucial, as using these diverse tools and RS can scaffold learners to form multiple solutions for the tasks at hand, while at the same time using different concepts. To address the second question, it is necessary to define the learners' model in terms of main learner difficulties in terms of the previously-mentioned network of concepts. To this end, the task of designers is to find ways to provide learners with opportunities to express and to overcome these difficulties, taking advantage of the tools provided. Finally, to address the third question, a model of learning was formed taking into account basic considerations of modern social and constructivist views concerning knowledge construction, while at the same finding ways to exploit the nature of tools of the e-learning environment provided to learners for interaction. The proposed scenario-based approach for the design of learning activities is presented analytically using a specific example for the study of the mid points of a triangle within the context of tools of Cabri-Geometry II .

Situating the concepts in focus within an intra-disciplinary context. Here, the mid points of the edges of a triangle are connected to the following essential mathematical concepts: a) parallelism, b) similarity in triangles, c) area in triangles, d) perimeter in triangles, e) medians, f) heights, g) sequences and h) limitations. A few words about the significance of the aforementioned concepts: the segment that connect the mid points of two edges of a triangle is parallel and equal to its third edge. Parallelism is a basic part of geometry and of sciences as well as of every day and professional life, as it is useful for constructors, architects and designers. Parallelism is also connected with the concept of vector, a significant concept in science. However, the segments that connect the mid points of the edges of a triangle also intersect its medians and heights. The concepts of both medians and heights are central in geometry as they are basic elements of plane shapes and also connected with the calculation of their areas. These concepts are also fundamental in science and engineering. Furthermore, when connecting two-by-two the mid points of the edges of a triangle, various similar shapes are produced. Similarity is part of mathematics as well as of every day and professional life. Similarity is also a useful concept, not only for designers and architects but also for all those who like to understand a map and also to measure distances that are impossible to measure directly. Similarity is also connected with the concepts of area and perimeter, which are also fundamental concepts in mathematics, science and engineering as well as in every day and commercial life. Discriminating area from perimeter is also substantial. By connecting the mid points of all the similar triangles produced starting from an original triangle, students can approach the concept of sequence through a tangible and meaningful example. The concept of sequence is fundamental to numbers theory as well as to economy and the development of algorithmic logic that is basic in computer science. By studying about sequences, students can develop their critical thinking skills, as they have to concentrate on the specific elements constituting a sequence and discover the pattern repeated. In our example, students have to concentrate on the sequence of triangles produced using the aforementioned method of construction, to discover the pattern that governs the relationship among their areas/ perimeters. By studying the sequence of these triangles, students can also approach the concept of limit of a sequence.

Learners' misconceptions and difficulties regarding the network of concepts formed: a) *parallelism*: Students find difficulties in drawing parallel lines, recognizing their parallelism when they are not horizontal and also not recognizing that the lines where specific parallel segments lie are also parallel. When some lines intersect outside the drawn area, students also recognize them as parallel lines. Finally, students face difficulties in recognizing the pairs of equal angles formed when two or more parallel lines are intersected by another line. b) *similarity in triangles*: Here, as well, students recognize similarity mainly when the similar shapes have parallel edges; needless to say, they usually confuse similarity with congruency. Students also have difficulty in recognizing the meaning of the ratio of similarity and that it has constant value for each pair of similar shapes. Sometimes, students also believe that the ratio of similarity of the edges of a pair of similar shapes remains the same when this ratio concerns the areas and volumes of these shapes. In general, students encounter difficulties in identifying what entity remains constant in similar shapes. Appropriate estimation of the homologous elements of the similar shapes is also another tricky task. c) *area in triangles*: Students usually encounter problems in discriminating area-units from length-units and use them interchangeably. They also confuse the concept of area with the concept of perimeter. In using area formulae, they also face problems in recognizing the true entities that participate in these formulae and try to produce numerical results by using the numbers given by the task at hand in any way they can. Students also do not easily understand that areas can be conserved while their forms could be altered. d) *perimeter in triangles*: First of all, students seemed to confuse area with perimeter. In addition, students do not easily recognize that there are shapes of different form but of equal perimeter. They usually recognize these shapes as congruent. e) *medians and heights*: Here, students confuse heights with medians. Sometimes they also understand that medians and heights are lines and not segments. As regards the concept of height, students usually recognize as the height of a triangle any segment that connects a vertex with the opposite side or any segment that connects two points each of which lie on two different edges of a triangle. Generally, students have difficulties in recognizing heights as perpenticular segments from a vertex of a triangle to its opposite edge, and especially when these heights concern obtuse-angled and right-angled triangles. Some students also believe that the median of a triangle separates it into two congruent triangles. f) *sequences*: the concept of a sequence is usually meaningless for secondary level education students as it is usually presented - in their schools - as a formalism without any reference to meaningful and familiar examples for the students. Students also encounter difficulties in finding the repetition pattern implied within a given sample of data included in a sequence and g) *limitations*. Here, as well, students usually view the concept of limitation from a static point of view, at the same time neglecting their dynamic dimensions. Students are also usually not provided in their schools with opportunities to make some meaningful sense of this concept, but formalistic considerations are emphasized.

Basic aspects of social and constructivist views of learning within Cabri-Geomery II. For the design of the proposed scenario-based activity, basic aspects of social and constructivist views of learning [1-4] were taken into account, at the same time acknowledging the development of MP of the concepts in focus. To this end, the role of appropriate and meaningful learning activities was also viewed as critical. Specifically, it was acknowledged that learning is an active, subjective and constructive activity within contexts rich in tools and RS. The role of providing learners with opportunities for exploration and experimentation and receiving appropriate intrinsic feedback on their actions is also viewed as critical.

3. Architecture and the interface design of the proposed scenario-based learning activities

Taking into account the analysis performed during the design stage, a network of concepts related to the concepts in focus has been specified. Also taking into account the analysis of students' difficulties with these concepts, a diversity of specific learning activities was also formed. The possibilities of Cabri Geometry II were also exploited for the formation of specific interactive constructions to support the performance of each learning activity in a consistent way with modern social and constructivist views of learning. As is shown in Figure 1, each interactive construction appears in the centre of the screen and can be managed through both direct manipulation and a navigation bar. Each part of this navigation bar consists of specifically-designed buttons dedicated to the management of a specific interactive construction. By using each of these buttons, a specific construction can be illuminated or hidden. When a specific interactive construction is illuminated on the screen, specific information is also presented to learners, such as: a) text-based information on the aspects related to the sub-activity at hand; b) appropriate questions, so as to assess student knowledge and c) instructions to manage the construction in focus. All these interactive constructions can be directly manipulated and possibilities for expressions of the related concepts in MRS are also formed. In our example, learning activities and the related interactive constructions were formed for the learning of the following concepts within the context of the construction of the segments connecting the mid points of the edges of a triangle; a) parallelism, b) similarity of in triangles, c) area in triangles, d) perimeter in triangles, e) medians, f) heights, g) sequences and h) limitations.

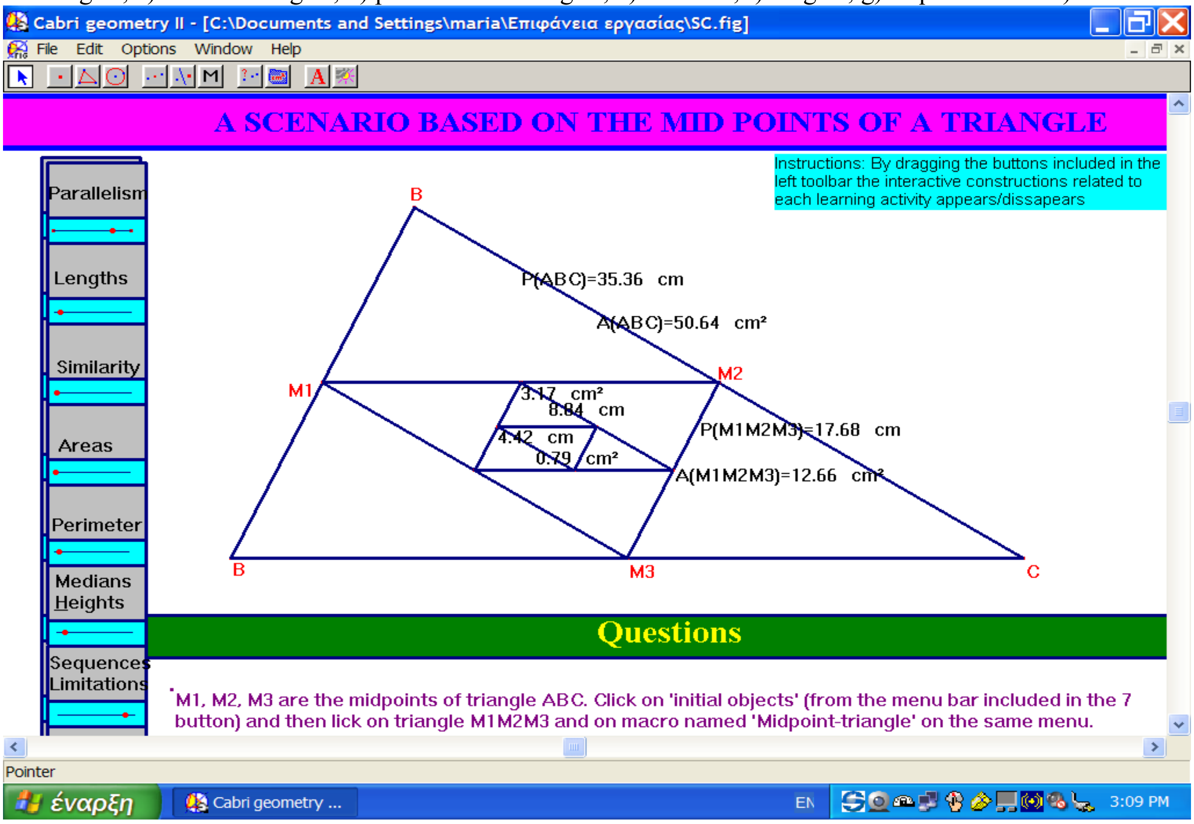

Figure 1. A typical interface of scenario-based activities within e-learning environments

4. Summary and plans for future work

This paper presented the idea of a scenario-based approach for the design of learning activities within e-learning contexts – such as the well-known educational software Cabri-Geometry II - providing diverse tools aiming to develop MP on the concepts in focus. For the design of such activities, a methodology was adopted consisting of a process of answering three fundamental questions, namely: a) what has to be learned, who the learner is and how the learning process takes place. To clarify the methodology proposed, a specific scenario-based approach for the learning of diverse mathematical concepts within the context of the construction of the segments connecting the mid points of the edges of a triangle was presented. To answer the first question, a network of concepts was formed so as to encourage intra-disciplinarity among the concepts in focus. To address the second question, students' main difficulties regarding the said network of concepts were also identified according to the relevant literature. Finally, to address the third question, basic considerations supported by social and constructivist views of learning within the context of the educational software used were also taken into account. Based on the analysis performed during this design process, various learning activities and interactive constructions were formed so as to provide students with opportunities to explore all the essential concepts included in the said network of concepts related to the subject matter in question, and especially those aspects where students encounter difficulties. All these constructions were realized so as to support constructivist learning. This network of constructions was fully integrated into the same interface manageable by specific buttons on a navigation bar. Field studies are necessary, to illuminate the impact of the design and implementation of this scenario-based approach on the development of MP on the concepts in focus by students.

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References

[1] D. H. Jonassen, Objectivism versus constructivism: Do we need a new philosophical paradigm?. Educational Technology Research and Development, 39(3), 5-14 (1991).
[2] D.H. Jonassen, Designing constructivist learning environments. Instructional design theories and models, 2, 215-239, (1999).
[3] B.A. Nardi, Studying context: A comparison of activity theory, situated action models, and distributed cognition. In B.A. Nardi (Ed.), Context and consciousness: Activity theory and human-computer interaction, (Cambridge, MA: MIT Press, 1996).
[4] L. Vygotsky, Mind in Society. (Cambridge: Harvard University Press, 1978).
[5] J-M. Laborde, Cabri-Geometry [Software]. (France: Universite de Grenoble, 1990).
[6] G. G. Wojnar, Intellectual Diversity: a Cornerstone of Critical Thinking. Retrieved on 08/03/09 from http://faculty.frostburg.edu/math/wojnar/Documents/wojnarIntellDivers.doc
[7] A. Collins, J. S., Brown, & S. E. Newman, (1989). Cognitive Apprenticeship. Teaching the crafts of reading, writing, and mathematics. In L. B. Resnick (Ed.), Knowing, learning, and instruction (pp. 453e493). Hillsdale, NJ: Erlbaum.
[8] R.J. Spiro, P.J. Feltovich, M.J. Jacobson & R. L. Coulson, Cognitive flexibility, constructivism, and hypertext: Random access instruction for advanced knowledge acquisition in ill-structured domains. In T. Duffy, & D. Jonassen (Eds.), Constructivism and the technology of instruction (pp. 57-76). (Hillsdale, NJ: Erlbaum, 1991).
[9] R.J. Spiro & J.C. Jehng, Cognitive flexibility and hypertext: Theory and technology for the nonlinear and multidimensional traversal of complex subject matters. In D. Nix, & R. J. Spiro (Eds.), Cognition, education, and multimedia: Exploring ideas in high technology (pp. 163-205). (Hillsdale, NJ: Erlbaum, 1990).
[10] H. Freudenthal, Didactical phenomenology of mathematical structures. (Dordrecht, The Netherlands: Reidel, 1983).
[11] M. Kordaki, 'MULTIPLES': a challenging learning framework for the generation of multiple perspectives within e-collaboration settings. In T. Daradoumis, S. Caballe, J.-M. Marques and F. Xhafa (Eds) 'Intelligent Collaborative e-Learning Systems and Applications', (Springer-Verlag, 2009, in press).
[12] C.S. Große and A. Renkl, Effects of multiple solution methods in mathematics learning. Learning and Instruction 16, 122-138, (2006).
[13] M. Kordaki, The role of multiple representation systems in the enhancement of the learner model. In Mendez-Vilas, A., Pereira, G., Gonzalez, Mesa J., and Gonzalez Mesa, J.A. (Eds), Recent Research Developments in Learning Technologies: 3rd International Conference on Multimedia and Information and Communication Technologies in Education. Caceres, Spain, June, 2005, pp.253-258.
[14] S. Ainsworth, DeFT: A conceptual framework for considering learning with multiple representations. Learning and Instruction 16, 183–198 (2006).
[15] H. Gardner, Frames of Mind: The theory of multiple intelligences. (New York: Basic Books, 1983).
[16] B. F. Skinner, The Technology of Teaching, New York : Appleton, 1968.
[17] NCTM, Principles and standards for school mathematics, (Reston, VA: NCTM, 2000).
[18] National Research Council, How people learn. (Washington D. C.: National Academy Press, 2000).