STEM and Collaborative Learning: An Alternative Approach

Stefanos Nikiforos, and Spyros Kolyvas

Abstract—STEM education in Greek schools has become more prevalent in recent years, mainly through the implementation of Educational Robotics projects. Small-scale working groups of handpicked participants constitutes the main practice of implementing these projects, aiming to participate in competitions for the purpose of discrimination. These projects are usually a parallel school activity concerning only the participants in it, having relatively little impact on school community. An alternative teaching approach is proposed and applied in the present research consisting of collaborative activities between volunteer participants who created a learning community. Results show that the proposed method satisfied students and generated their interest in both the future engagement with Robotics and the participation in similar collaborative activities.

Index Terms—Collaborative Learning, Educational Robotics, Learning Community, STEM, Wiki.

I. INTRODUCTION

A. Educational Robotics (STEM)

Educational robotics is rapidly growing globally, offering a new dimension to the narrow boundaries of the school class, causing substantial changes in teaching and learning [1]. Papert considers that use of robotics can improve teaching process, enabling students to approach school’s subjects in an attractive way [2]. It promotes cross-linking of different scientific fields through collaborative learning environments, creating positive climate. Research so far shows that students been taught robotics increased their knowledge and their interest, having better performance [3]-[4].

Today Robotics is an important part of global educational activity. Students who design and construct robots have the opportunity to learn, while playing. They improve their collaborative skills, creativity and computer skills. Students’ involvement in solving real world open problems ensures effective knowledge building.

B. Learning Communities and Collaborative Learning

Learning communities consist a new pedagogical model for innovative learning [5]. Strong feelings of the community not only can increase interest for the lessons, but they also increase the commitment to achieve goals, collaboration, satisfaction and motivation for learning [6]. Strong community sense prevents negative behavior. Students are more connected to the school, participate in school activities, make decisions and have common standards, goals and values [7].

Collaborative learning leads to the discovery of knowledge through practice, relying on the experience and the existing knowledge of the students. Students deal with authentic problems that fit into their experiential space [8]. Students, through their social interaction, both with their peers, the teachers and the wider social framework of support, build their own mental world, based on past knowledge and experiences [9]. Moreover, modern learning theories emphasize the importance of the social context in which learning and interaction among students takes place [10].

Collaborative environments, such as wikis, provide the ability to transform a Physical Learning Community (PLC) into Virtual Learning Community (VLC). Existing social relationships among members in PLCs are further cultivated and empowered, since the early stages of their online communication, due to their previous interactions [11]. Students have the opportunity to learn together through wikis, to exchange knowledge and collaborate to solve problems. Wikis contribute effectively to the development of collaborative skills [12] and they are directly related to the concept of social constructivism [13].

Dialogue perspective fits with Computer Supported Collaborative Learning (CSCL), as the advantages of new technologies in education are particularly suited to promote students’ dialogues and deepen and broaden these dialogues [14]. Argumentation and dialogue are processes that promote learning [15]. At each stage, there are specific objectives supported by appropriate teaching interventions and actions that gradually transfer decisions and control of work from the teacher to the student.

In Greek school dominant ways of organizing the class remain competitive and individual [16]. Teacher should attempt a new open pedagogical approach that extends and strengthens learning, responding to present reality, and students’ needs. In collaborative learning the teacher adopts the demanding role of the “orchestrator”. Using various tools, he is called upon to coordinate student groups [17]. His role is mainly enhancing, animating and providing feedback.

II. AIMS AND SCOPE

Aim of this research was the design of an alternative teaching approach, offering a predominant role to students. They learned through the game in a democratic context. Objectives and methods were customized according to their cognitive level. Selection criteria of their participation were

Published on February 17, 2020.
S. Nikiforos is with the Humanistic and Social Informatics Laboratory (HILab) in the Department of Informatics, Ionian University, Greece (e-mail: c13nik@ionio.gr).
S. Kolyvas is an art teacher in primary education (e-mail: kolyva00@gmail.com).

DOI: http://dx.doi.org/10.24018/ejers.2020.0.CIE.1793
Kit construction tools (LegoMindstormsNXT) were used for the construction of the robotic device. Learning was done through construction, the idea of "learning to build" is within the framework of the constructivism philosophy. Robot construction kits are widely used in training, designed to allow the students to create any shape or kinetic chain for their robot [19]. It is considered that the learner's experiences, knowledge and needs are expressed through construction [20]. Thus, realization of a construction is an ideal didactic intervention for the elevation, exploitation and evaluation of the cognitive structures of each student. Our teaching approach is alternative than the usual practice, where teachers divide students into small groups based on the criterion of their excellence. Our selection of students was neither based on mental skills test, nor on their competence in computer knowledge.

Students initially formulated their thoughts through drawing and painting. Sessions took place on a flexible design, also utilizing the wiki environment, which allowed students to continue their work outside the school unit, strengthening even more the members' bonds. Special attention was paid to the inclusion of the web-based collaborative platform (Wikispaces) in the educational process, aiming at maintaining its collaborative role, while not detracting from the importance of physical presence and face to face communication [10].

This approach aims to be an alternative learning method combined with play and pleasure, rather than with conventional learning obligations. Typically, in the game, competition between teams is developed. Some believe that inter-group or individual competition can promote learning and improve student performance, if the teacher manages it efficiently [21]. Students were divided into three (3) mixed groups in order to have a meaningful interaction and acquaintance with each other. First subgroup dealt with the robotic construction - platform, the second one with its programming, while the third one was concerned with design and construction of the maquette, on which the robot would move. Through dialogue and discussion, students decided to deal with future transportation: a moving platform (bus) passing through historic buildings of the city with particular architectural, cultural and symbolic value.

Our teaching approach combines basic robotics elements and visual elements, such as the creation of a maquette. It introduces robotics as a learning tool for students' involvement in problem design and exploration activities, which culminate with a final product [22]. Project was implemented in three phases:

a) Students, inspired and motivated by the teachers, chose a subject based on the desired learning outcomes. This helped students to formulate specific questions that guided their work.

b) Students worked in small groups to explore concepts associated with the general project (reflection). Teachers participated along with the students in the cognitive processing and the analysis of the data that motivated students' superior cognitive functions in a collaborative learning process. As supporters and animators, they strived to create equal opportunities for success for all students by helping them in the context of collaborative learning to transform their

DOI: http://dx.doi.org/10.24018/ejers.2020.0.CIE.1793
personal vision into collective.

c) Final phase of the proposal is characterized by the culmination of the activity where, with the teachers’ aid, a summary of the project results was made.

Students had the opportunity to express their views on the robotics design, the history of their place, and the aesthetics as well. A community with "intellectual content" was formed. The mediator-teacher, in order to strengthen both the bonds between the members and their interest in their connecting relationships, helped to cultivate the sense of "belonging" in the community for all the participants.

III. RESULTS

Present research sought to explore students’ attitudes towards robotics. Data collected are presented through descriptive statistical analysis (frequencies) due to the small sample.

62% of the participants had not any previous knowledge on robotics. Despite this fact, majority (83,8%) of the students had a positive experience; they were satisfied of the subject of the program (81,1%) and considered robotics as very interesting (62,2%). 39,4% of students were impressed by the robot design and manufacturing, 21% by the robot programming, and 15,85% by the design and construction of the maquette. 18,4% were impressed by all of the above mentioned, while a small percentage (5,2%) stated that none was impressive. These results agree with the survey of [23].

Majority of the students (62,1%) intended to engage in robot construction and programming in the future, while 13,5% preferred the design and the construction of the model and 18,9% preferred to deal with all the above mentioned. 79% of the students did not need any help of their teachers, while 21% of them needed their help many times. Vast majority of students (Fig. 1) had not ever been taught in a similar way (in a program or a lesson).

Majority of the students (56,7%) did not have any particular difficulties in completing the project, while a very small percentage (2,7%) had great difficulty. Vast majority (64,8%) of the students regarded their robotic collaboration as excellent. A small percentage (2,6%) considered that collaboration was non-existent.

IV. DISCUSSION

Different grade’s students participated in the current robotics project. Special emphasis was given on this kind of participation, in order to create mixed working groups aiming at collaboration and interaction between students with different cognitive levels and skills. Students participated freely, been previously informed about the aim of the project. There was not any restriction concerning their learning abilities or their behavior. This is a differentiation, as in Robotic projects, selection of students is usually based on their learning ability or behavior. It is customary for such projects to be attended by the finest and most quiet students.

Results from this research show that the overwhelming majority of students gained positive experience from engaging in the specific robotic project, and considered it as a very interesting. This view comes in agreement with [3] who argue that students showed greater interest and had better performance in the lessons been taught through robotics. However, a large percentage of the participants (62%) had never heard of robotics projects. This highlights the need to promote such projects, as well as the need to provide support and encouragement to teachers who undertake these projects. Also, the overwhelming majority of the students had not ever been taught in a similar way of teaching in the past. However, majority of students stated that they wish to learn in the future with a similar teaching method to that of robotics. They were also satisfied with the subject of this project, as a result of their participation, both in the choice of the subject and in the design and its implementation.

Majority of the students did not need help of the teachers and had no particular degree of difficulty in completing the project, which is in line with the research of [24]. It seems that creation and collaboration among mixed teams of students -different grades and consequently different cognitive levels and skills- worked properly. Survey data confirm that the collaboration of the participants in the robotics project was excellent. Students took the role of the trainer/facilitator of learning on several occasions. Previous
research show that such activities promote collaborative learning [25]-[24]. Results also showed that participation of the students in the selection of the topic is related to the positive view of their participation experience, as well as to the increase of their participation in similar programs in the future. Furthermore, level of collaboration among the participants in the project affected positively their experience.

V. CONCLUSIONS AND FUTURE WORK

Introduction of Robotics in Education offers the possibility of the direct involvement of the students in the learning process, the cultivation of reflection through the possibility of self-correction, the immediacy of feedback and the satisfaction of achieving the goal. Implementing this project, students set up a learning community with the willingness to jointly create a learning environment, through the interaction of mixed grade's students and different cognitive subjects, having a common goal of successfully completing the project. Students experienced a new way of discovering knowledge through collaborative learning. Encouraging students to solve collaboratively real problems is an effective way of learning [26]. Students’ interest throughout the implementation of this teaching proposal was great. Therefore, it is proposed that the above methodology can be gradually applied to the teaching of various courses, which will contribute to the stimulation of interdisciplinarity and to familiarizing students with the modern technologies and the basic concepts of programming. However, in order to reach a safe conclusion on whether and how robotics affect cognitive, social skills and stimulate self-esteem and self-confidence of students, or if it is temporary and transient, long-term and systematic research is required [27]-[28]. It is not always easy to design robotics activities to support collaborative learning, as there are very few examples of teacher guidance [29].

REFERENCES

[1] Ackermann, E. (2001). Piaget’s constructivism, Papert’s constructionism: What’s the difference. Future of learning group publication, 5(3), 438.

[2] Papert, S. (1993). The children’s machine: Rethinking school in the age of the computer. BasicBooks, 10 East 53rd St., New York, NY 10022-5289.

[3] Nugent, G., Barker, B., Grandgenett, N., & Adamchuk, V. (2009, October). The use of digital manipulatives in k-12: robotics, GPS/GIS and programming. In 2009 39th IEEE Frontiers in Education Conference (pp. 1-6). IEEE. DOI: 10.1109/FIE.2009.5350828

[4] Mintik, R., Nussbaum, M., & Soto, A. (2008). An autonomous educational mobile robot mediator. Autonomous Robots, 25(4), 367-382. DOI: 10.1007/s10119-008-9101-z

[5] Palloff, R. M., Pratt, K., & Stockley, D. (2001). Building learning communities in cyberspace: effective strategies for the online classroom. The Canadian Journal of Higher Education, 31(3), 175.

[6] Bruffee, K. A. (1993). Collaborative learning: Higher education, interdependence, and the authority of knowledge. Johns Hopkins University Press, 2715 N. Charles Street, Baltimore, MD 21218-4319.

[7] Battistich, V., & Horn, A. (1997). The relationship between students’ sense of their school as a community and their involvement in problem behaviors. American journal of public health, 87(12), 1997-2001. https://doi.org/10.2105/AJPH.87.12.1997

[8] Bigge, M. (1990). Learning theories for teachers. Athens: Patakas (in Greek)

[9] Rieber, R. W., & Carton, A. S. (Eds.). (1993). The Collected Works of LS Vygotsky: The Fundamentals of Defectology (Abnormal Psychology and Learning Disabilities). Springer US.

[10] Meliadou, E., Nakou, A., Gouskos, D., Meimaris, M. (2011) Digital Storytelling, Learning and Education in A. Lionarakis (ed). 6th International Conference on Open & Distance Learning - November 2011, Loutraki, Greece. (in Greek)

[11] Kiesler, S., Siegel, J., & McGuire, T. W. (1984). Social psychological aspects of computer-mediated communication. American psychologist, 39(10), 1123. http://dx.doi.org/10.1037/0003-066X.39.10.1123

[12] Lu, C., Wang, Q., & Lei, J. (2012). What factors predict undergraduate students' use of technology for learning? A case from Hong Kong. Computers & Education, 59(2), 569-579. https://doi.org/10.1016/j.compedu.2012.03.006

[13] Chen, H. L., Cannon, D., Gabrio, J., Leifer, L., Toye, G., & Bailey, T. (2005). Using wikis and weblogs to support reflective learning in an introductory engineering design course. Human behaviour in design, 5, 95-105.

[14] Wegerif, R. (2006). A dialogic understanding of the relationship between CSCL and teaching thinking skills. International Journal of Computer-Supported Collaborative Learning, 1(1), 143-157. https://doi.org/10.1007/s11412-006-6840-8

[15] Andriessen, J. (2006). Arguing to learn. In: K. Sawyer (Ed.), Handbook of the Learning Sciences (pp.443-459). Cambridge: Cambridge University press.

[16] Charalambous, N. (2000). Collaborative learning: from theory to practice. Scientific Symposium: The Application of the group-centered Teaching Trends and Applications, Thessaloniki. (in Greek)

[17] Roschelle, J., Dimitriadis, Y., & Hoppe, U. (2013). Classroom orchestration: synthesis. Computers & Education, 69, 523-526. https://doi.org/10.1016/j.compedu.2013.04.010

[18] Carbonaro, M., Rex, M., & Chambers, J. (2004). Using LEGO robotics in a project-based learning environment. The Interactive Multimedia Electronic Journal of Computer-Enhanced Learning, 6(1).

[19] Basoeki, F., Dalla Libera, F., Menegatti, E., & Moro, M. (2013). Robots in Education: New Trends and Challenges from the Japanese Market. Themes in Science and Technology Education, 6(1), 51-62.

[20] Resnick, M., & Ocko, S. (1991). LEGO/Logo: learning through and about design in: Harel, I. & Papert, S.(Eds.) Constructionism.

[21] Noguez, J., Huesca, G., & Sucer, L. E. (2007, October). Shared learning experiences in a context environment within a mobile robotics virtual laboratory. In 2007 37th Annual Frontiers In Education Conference-General Engineering: Knowledge Without Borders, Opportunities Without Passports (pp. FG-15). IEEE. DOI: 10.1109/FIE.2007.4417882

[22] Clark, A. (2006). Material symbols. Philosophical psychology, 19(3), 291-307. https://doi.org/10.1080/09515080600609872

[23] Kyriakou, G., & Fachantidis, N. (2012). Teaching of Informatics with Applications of Educational Robotics, based on Constructive theory, 6th Computer Science Teaching Conference, ETPE 2012. (in Greek)

[24] Chronaki, A. and Kourias S. (2011). Kids, Robots and Lego Mindstorms: recording the beginning of an interactive relationship. In the Proceedings of the 2nd Pan-Hellenic Conference on the Integration and Use of ICT in the Educational Process, 1009-1020, Patras. (in Greek).

[25] Kreans, S. A., Rogers, C., Barosky, I., Portsmore, M., & Rogers, C. (2001). Successful methods for introducing engineering into the first grade classroom. In ASEE Annual Conference and Exposition Proceedings, Albuquerque, New Mexico.

[26] Nelson, L. M. (1999). Collaborative problem solving. Instructional design theories and models: A new paradigm of instructional theory, 2, 241-267.

[27] Alimisis, D. (2013). Educational robotics: Open questions and new challenges. Themes in Science and Technology Education, 6(1), 63-71.

[28] Chiou, A. (2012). Teaching technology using educational robotics. In Proceedings of the Australian conference on science and mathematics education,9-10.

[29] Kamga, R., Romero, M., Komis, V., & Mirsili, A. (2016, November). Design requirements for educational robotics activities for sustaining collaborative problem solving. In International Conference EduRobotics 2016 (pp. 225-228). Springer, Cham. https://doi.org/10.1007/978-3-319-55533-9_18.

DOI: http://dx.doi.org/10.24018/ejers.2020.0.CIE.1793
Stefanos Nikiforos graduated from the Department of Primary Education, University of the Aegean, in 1994. He received his M.Sc. in Informatics on Humanities from the Department of Informatics, Ionian University, in 2013. He is currently a Ph.D. student at the same department. His research interests include Natural Language Processing (NLP), Virtual Learning Communities (VLCs), Linguistic Data Mining, Computer Supported Collaborative Learning (CSCL), Machine Learning.

Spyros Kolyvas graduated from the Department of Theology, National and Kapodistrian University of Athens, Greece in 1992. He received an Integrated master from the School of Fine Arts, Athens, Greece, in 1999. He also holds a Master (M. ED) in Education of the Greek Open University. He has received a national scholarship and a prize for his study in the School of Fine Arts in Athens. His research interests include Organizational Culture, Culture of Trust and School Efficiency, Innovation in Education, Collaborative Learning, Collaborative Learning Environments, Fine Arts, Art History. He is a member of the Visual Chamber of Greece.