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Article

Hanoi Towers

Hanoi Towers: A Game-Based Approach for the Introduction to Programming by using Educational Robotics

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Abstract
The study presents a model approach to the teaching of basic programming structures by using the method of game-based learning. It was used the Educational Robotics which is considered, according to its characteristics, as an ideal way for teaching a lesson in a game-based approach. The study displays a case study, the resolution of the Hanoi Towers' problem. It presents strategies and teaching methods, conclusions and results of a case study which was implemented on students of the 1st and the 2nd grade of Senior High School.

Keywords: Programming Structures, Educational Robotics, Game-based Learning, Case Study

Introduction

The teaching of ICT and the way in which it should be done in High School grades, is something which has concerned the Educational community over the last few years. The Educational Robotics, the reasons why this choice is preferable will be developed below, can be described as an interesting choice for the introduction of the student in the Programming environment, the computational thinking and the teaching of basic programming structures. Over the last few years we have noticed the integration of Educational Robotics into the teaching of subjects which belong to the STEM field (Science, Technology, Engineering, Mathematics). The Educational Robotics possesses a game-based character which can be used for the accomplishment of the learning goals. The game-based learning is a teaching method which, in the course of time, has concerned the experts on the fields of Education and Psychology.
This study shows the results of a case study, which made use of the game-based character of Educational Robotics for the teaching of basic programming structures into a pleasant and entertaining environment, which is easily comprehensible even for a student who had no previous experience and knowledge on programming environments. The strategies and the learning methodology will be developed as well as the results and the assessment of the case study will be presented in the content of this project.

Objectives

The main objective of this study was to introduce to the participating students the potential of Educational Robotics through game-based learning.

The other specific objectives were:

- To develop interdisciplinary work, promoting the integration of concepts of Programming, Engineering and Technology.
- To develop transversal skills, such as critical thinking, computational thinking, problem solving and team work.
- To stimulate the theoretical study of the content.

Educational Robotics

The Educational Robotics contributes to the increase of the quality of scientific and technological education in all school types, from pre-school age to tertiary education. It is an effective learning tool because it helps create a fun and engaging learning environment that keeps students interested and engaged in learning.

The Robotics technology has become a popular educational tool which has increased the students' interest in programming, artificial intelligence and robotics. It is primarily suitable for the teaching of STEM, but it can also be connected with other fields such as Literacy, Theatre, Arts (Nikolos & Komis, 2010). The Educational Robotics provides the potential for the development and simulation of real situations, the involvement of many scientific fields and the cooperative learning and it is consistent to the principles of exploratory learning and Inter-thematic approach of knowledge (Alimisis, 2009; Sotiriou et al., 2012). Furthermore, it encourages students to get engaged into the learning process while it is clearly about a student-centred approach. During the process of designing and programming of robots, the students receive basic knowledge on mechanics, mathematics, and computer technologies (Druin and Hendler, 2000; Arlegui et al., 2008).

The Educational Robotics can develop the students' inquisitive skills, allows students to put forward several hypotheses, conduct experiments and cultivate abstract skills (Papert, 1993). From this point of view, Educational Robotics can serve ideally the principles of Inquiry-based Learning.

In the whole Europe, there are programmes which encourage the incorporation of Educational Robotics in schools, such as the TERECoP programme (www.terecop.eu), the Robot@scuola in Italy (http://www.scuoladirobotica.it/en/RobotAtScuola/index.html), the CENTROBOT in Austria and Slovakia (http://www.centrobot.eu) and many more. At the Media Lab of M.I.T. was created "The Lifelong Kindergarten group", which developed several Educational Robotics scenarios, which goals are the exploration of the mechanic motion principles (Learning about motion) as well as the creation of a package of tools and activities which are suitable and can be used even from artists for the creation of Art (Robotic Art Studio). For the full list of activities of M.I.T. refer to: https://llk.media.mit.edu/projects/.

Game-based Learning

The importance of playing during the pre-school and school age, as well as its impact on children's growth, is a matter that has concerned the experts of Education and Psychology in the course of time. According to Plato "Learning through Education and delight" (Konstantinidou, 1988). Piaget (1962) considers playing as an adaptable behaviour that helps the development of children's thought, while Vygotsky suggests that playing is an opportunity for children to learn more things about their world, discover new ideas and enhance their imagination. There are parents who believe that their children's playing is a waste of time, seeing that this given time should be invested on school duties (Golinkoff et al., on publication). On the other hand, it is widely believed that the time our child spends playing, is a learning time. Playing is the means which has a positive effect on the complete development of children. Especially for the children who are at school age, playing is a means of relaxation and relief of the daily tension. In fact, taking into account the Finnish educational system, we can see that they have integrated playing into the analytical school curriculum and this way they have given children the opportunity to express themselves openly and reduce the stress which is caused by the teaching procedure.

Methodology

The study case is an extracurricular activity that was implemented in a public High School. The teaching procedures took place after the end of the daily school timetable, in the Informatics Lab and they applied to students who voluntarily participated in the programme. The aim of this educational practice was the teaching of the basic programming structures (sequence-loop-choice structure). There were nine (9) students of the 1st and the 2nd grade of High School who attended the programme and were divided in three (3) groups of three(3) students each one, according to the principles of constructionism (constructionism or constractivism). The students were already aware of the programming environment of free software "Scratch". The most popular Lego's robotic kit, the EV3 Mindstorm, was used in the present educational practice. The educational programming capability of simulating real-time situations, makes it ideal for the implementation of the exploratory learning principles. The educational procedure through the exploration of a natural or constructed (simulated) social environment lead the students to pose questions and make discoveries in search of new knowledge acquisition. With this educational strategy, children learn about sciences while they implement them (Aubé & David, 2003). The Inquiry-based method according to the "Learning by Doing" principle was implemented in the teaching procedure (Dewey, 1997). It is about a social-constructivism learning method, because it encourages cooperation among the students for the finding of resources, the use of tools and the publication of results. In this way, the students make progress through cooperation, conversation and reciprocal help. The students acquire knowledge more through questions, hypotheses, experiments, observations, analysis than through exposure to knowledge by educators and memorization (The Pathway Project, 2013). In the present educational practice, there has been an effort in order to involve the student into the creation of questions, the research, the finding of suitable answers, conversation and feedback in association with the results (Bishop et al., 2004). The aim of this activity was to involve students into an active

learning, based ideally on their own questions. The problem which was used into the case study is the well-known problem of the Hanoi Towers. It is about a problem with a game-based character and the Educational Robotics is ideal for its resolution.

The programming environment of EV3 Mindstorm

The language of EV3 is the one which was created by Lego, for the programming of the robotic kit Mindstorm (Figure 1). This language constitutes the evolution of an older language NXT-G. It is about a language with programming in "line", in a particularly friendly and graphical environment. However, it has the potential of creating complex programmes, parallel programming and record of Data Logging (http://en.wikipedia.org/wiki/Lego_Mindstorms_NXT). In the case study, there was check carried out on the three (3) engines through the distance sensor, the gyro sensor and the contact sensor.

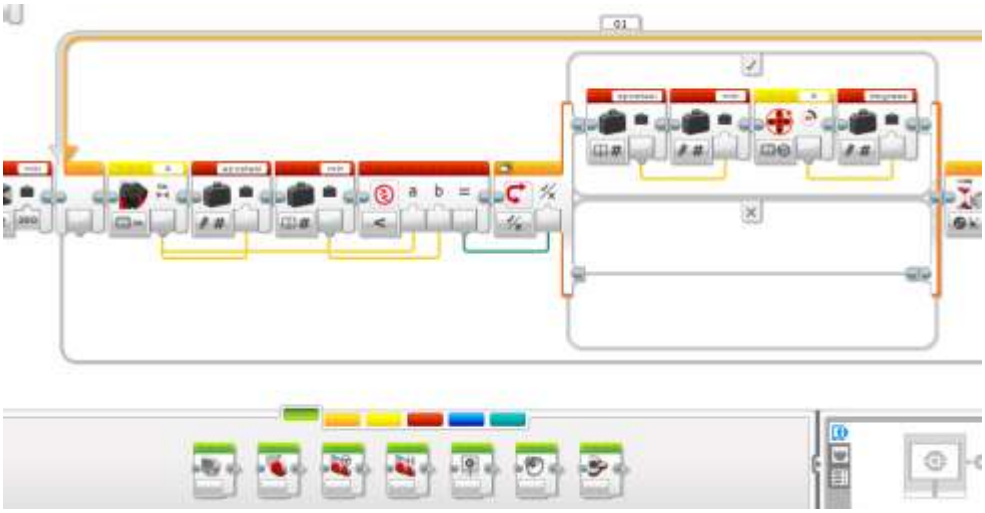


Figure 1: The EV3 Programming Environment

The Case Study

Four(4) two-hour lessons took place. Before each activity, there was a combination between the existing knowledge and the subject under review. Next, the students posed questions and made hypotheses in order to find a resolution to the problems. After the implementation of the solutions that the students proposed, there was an analysis by the students of the reasons why a solution was successful or not. There was communication among the groups in order to find a solution or a mistake made by a group. In the end, after the resolution of the problem, the groups were supposed initially, to create their own problem and then, choose whether to give it to the other group in order to solve it or to find the problem's solution themselves (feedback stage).

The lessons that took place, analytically:

- Lesson1: Introduction to Educational Robotics (Introduction - Learning of environment - Orders). There was a small introduction to the language and its environment. The basic orders as regards the robot's control were presented.

- Lesson2: Presentation and analysis of the problem. The Hanoi Towers problem was presented and analysed. The students solved the problem into a real-time situation by reconstructing themselves the movements of the robotic arm, which will be used for the resolution of the problem.
- Lesson3: Construction. With the teacher's help, the students constructed a robot arm with 3-degrees of freedom (Figure 2). The arm has the ability to catch, lift and transfer wheels which depict the Tower's discs. It is about a complex construction and for its creation, the students relied on the existing designs of arms, which they adapted on our case.
- Lesson4: Programming. The lesson of programming was divided in two stages:

Firstly, the solution of the problem was found by using a tablet with Android OS and Lego Mindstorm Commander. With this particular application, the students were able to give orders, drive, tele-control the arm. Thus, they found out the functionality of the construction and which steps they should follow, so that the arm can become a really automatic system. Next, the programming on EV3 language and the complete automized solution of the problem followed (Figure 3).

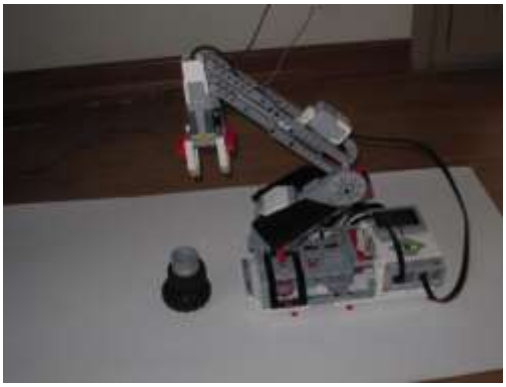


Figure 2:The robotic arm

Figure 3:The programming phase

Remarks from the lessons conduct:

-The students had no previous knowledge on EV3 programming environment. That is the reason why the first lesson was the introduction to the language of programming.
-The level of students' knowledge on programming was restricted to the knowledge of programming on Scratch, in the context of the school lesson of Informatics.
-The instructed method was chosen for the construction, because of the limited time and lack of students' experience on congruent constructions. There was an adaptation, though, according to our problem.
-Firstly, there was a resolution of the problem with the use of orders by the implementation of tele-control, so that the students can have their first contact with the resolution of the problem through a procedure with a game-based character. Through this particular procedure, there were some measurements and final adjustment on the construction of the robot arm.

-The resolution using retrospection was not chosen, because it was decided that the teaching of basic programming structures was of much importance, like sequence, choice and loop. In the end, though, there was a high level of comprehension by the students.

Evaluation

After the end of the lessons, the students were given a questionnaire so that we can evaluate the programme based on the students' answers. The answers provided us with useful conclusions.
In the question "What is your opinion about the learning of programming using Educational Robotics?" the majority of the students answered that this type of learning was interesting, useful and exciting (Table 1).

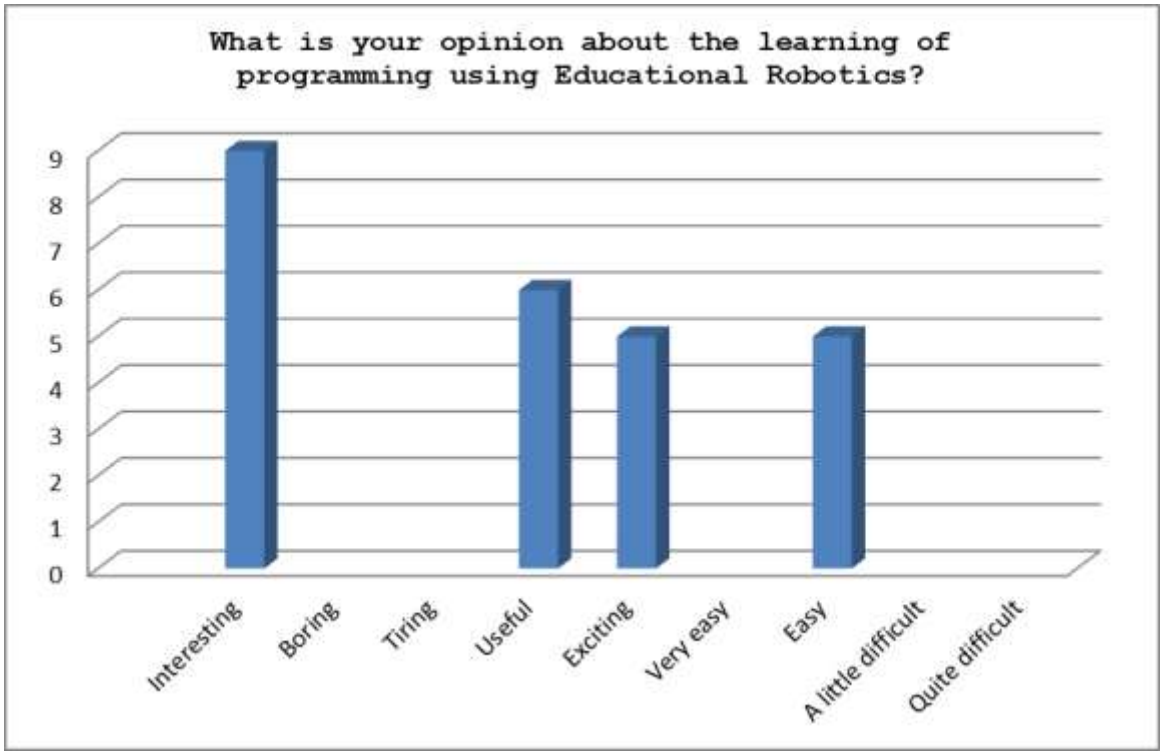
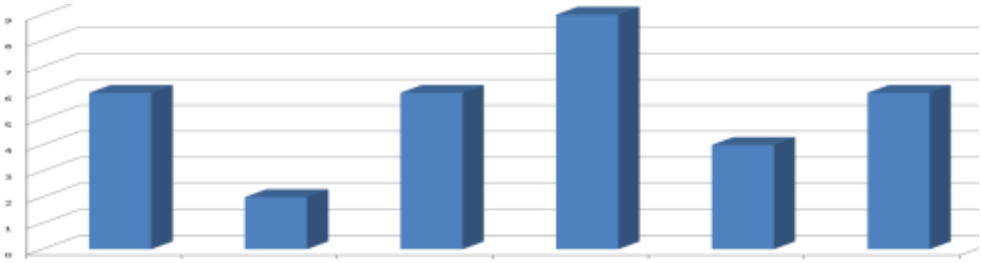


Table 1: What is your opinion about the learning of programming using Educational Robotics?

In the question "Did you like the Educational Robotics lessons and why?", the students answered positively, pointing out that they learnt how to programme, they experimented, while the lesson develops a game-based character (Table 2).

Also, it seems that the students liked the teaching of programming.



The lesson developed a game-based character	The time passed more pleasantly	What we were programming was before our eyes	We learnt to program more easily	We cooperated all together	We did some experiments

Table 2: Did you like the Educational Robotics lessons and why? How much did Educational Robotics help you to solve the Hanoi Towers problem?

Next, the question "To what extend did the Educational Robotics help you to solve the Hanoi Towers Problem?". From the answers, which were positive as a whole, it appears that the Educational Robotics helped to the comprehension of the problem, the planning and the programming of the solution, it gave the incentive for the resolution, while with the capability of real-time situations simulation, it helped the students solve the problems.

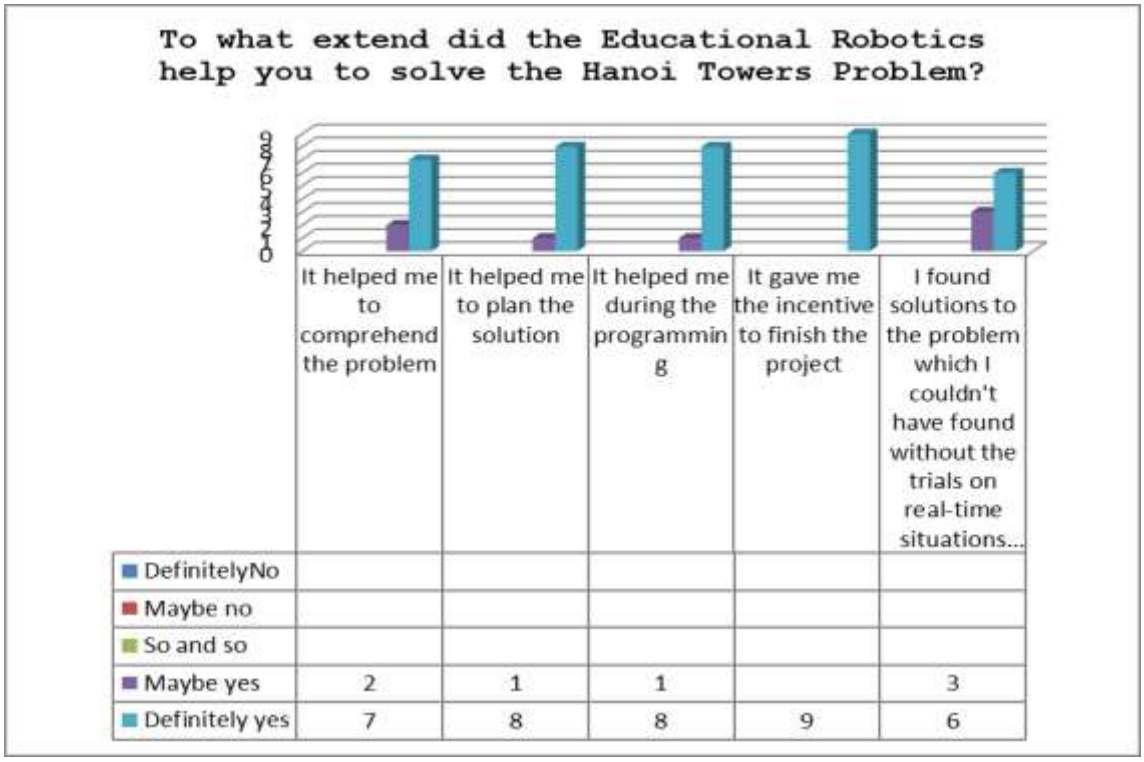
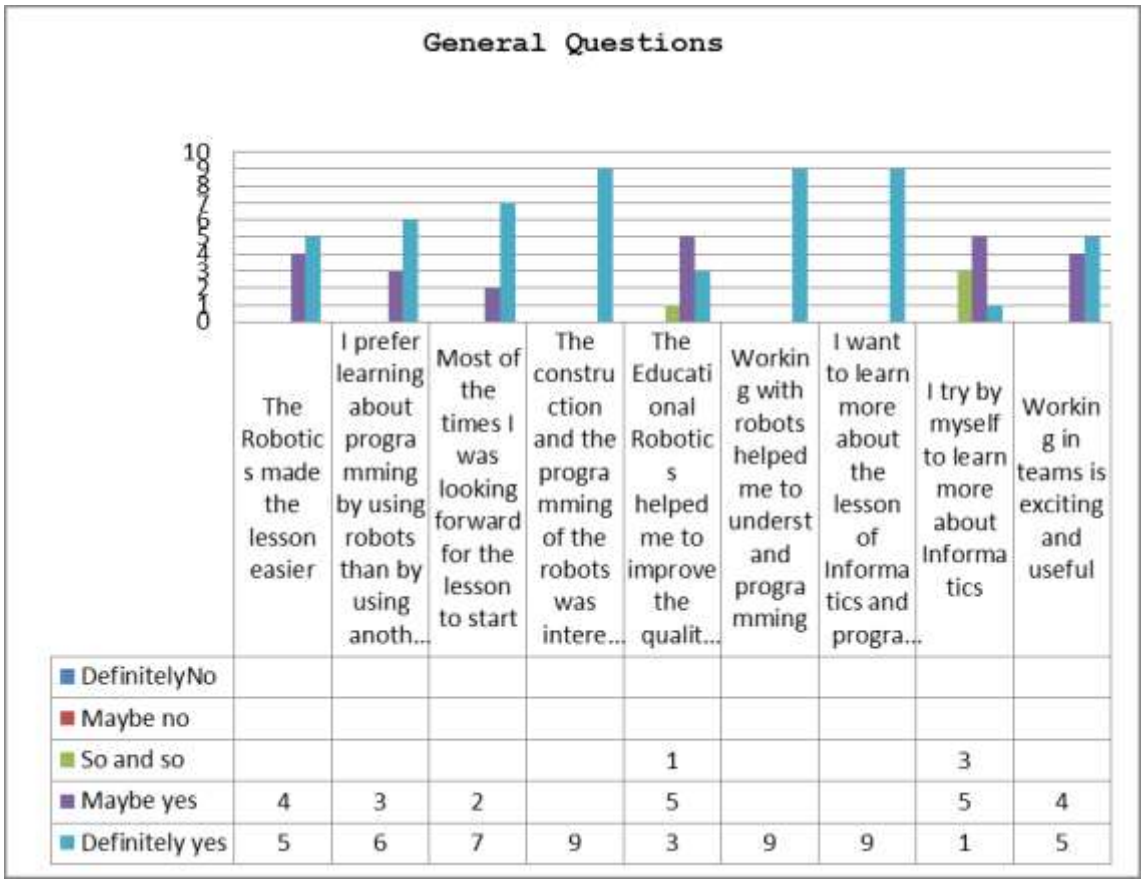


Table 3: To what extend did the Educational Robotics help you to solve the Hanoi Towers Problem?

Finally, the students were asked to mark the sentences they were agreeable to:

1 The Robotics made the lesson easier
2 I prefer learning about programming by using robots than by using another programming environment on the computer screen
3 Most of the times I was looking forward for the lesson to start
4 The construction and the programming of the robots was interesting/exciting
5 The Educational Robotics helped me to improve the quality of my school assignments
6 Working with robots helped me to understand programming
7 I want to learn more about the lesson of Informatics and programming
8 I try by myself to learn more about Informatics
9 Working in teams is exciting and useful

From the students' answers we come to the conclusion that the lessons have a game-based character, they were pleasant and interesting for the students (Table 4). The students were looking forward for the lesson to start while, at the same time, the lesson was interesting/exciting. In the question, whether working with robots helped them understand the programming, the answers were positive as a whole, while, all the students expressed their desire to learn more about programming after the completion of the teaching procedures.



	The Robotics made the lesson easier	I prefer learning about programming by using robots than by using anoth...	Most of the times I was looking forward for the lesson to start	The construction and the programming of the robots was intere...	The Educational Robotics helped me to improve the qualit...	Working with robots helped me to understand programming	I want to learn more about the lesson of Informatics and progra...	I try by myself to learn more about Informatics	Working in teams is exciting and useful
DefinitelyNo									
Maybe no									
So and so					1			3	
Maybe yes	4	3	2		5			5	4
Definitely yes	5	6	7	9	3	9	9	1	5

Table 4: General Questions

Conclusions

From the evaluation of the answers, we can see that the Educational Robotics made the students interested in programming and the majority of the students want to engage themselves more in programming. At the same time, the students answered that they learn to work in groups in a constructive way. Moreover, it is proved that the acquisition of scientific knowledge, the learning of programming in this specific case, the understanding of principles which rule the natural world and the skills development, are possible to be successful with the use of Educational Robotics through the appropriate exercises-activities by using the appropriate methods of knowledge approach such as the game-based learning. It is recommended that appropriate scenarios be created which can be used by teachers who want to introduce the Educational Robotics into the teaching of Informatics.

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