RESEARCH ARTICLE

Implementation and evaluation of a remote seminar on the pedagogical use of educational robotics

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Abstract: This article describes distance teacher training for educational robotics' pedagogical use, *e.g.*, the planning, the implementation, and the evaluation by the teachers involved. The training seminars were organized as part of the Greek eTwinning community's seminars. They were based on a Teacher Practice Community of the South Aegean about using ICT in teaching practice. From 2018 we have included seminars on educational robotics. There is a growing interest in the use of educational robotics in teaching practice. Although the topic is such that face-to-face contact and experimentation with the subject is considered necessary, we tried to educate teachers using remote learning methodology. The project was successful, and the evaluation of the seminars was very positive.

Keywords: educational robotics, teacher training, eTwinning, communities of practice

1 Introduction

1.1 Teacher training in the didactic use of ICT

Our contemporary society demands the constant retraining of people, which automatically converts our traditional education practice to a sole part of our educational system. Most research studies ascertain that educational systems' problems are primarily problems of the educators themselves, relevant to vocational development, further training, postgraduate courses, and the drawbacks of their basic training. At the same time, the establishment of lifelong learning should be under consideration in relation with all the social powers to which it refers and should refer to all kinds of learning (typical, non-typical, atypical), allowing the establishment of one constant group of educational activities (Kalogiannakis & Papadakis, 2019).

Teacher education in information and communication technologies (ICT) is a priority both in research and in international organizations and educational policymakers (Shokri & Dafoulas, 2016; Kontogiannopoulou - Polydoridi 1995; Raptis & Rapti, 2000; European Commission, 2003). In Greece, teacher training was implemented with various small projects of the European Union and large projects of "education level A," in which more than 100,000 teachers have been trained in basic computer skills. Additionally, there were level B projects for about 30,000 teachers who have been trained in the use of the Internet and educational software in teaching practice.

Teachers today must use ICT and integrate them into the lesson, utilizing the vast potential they offer to upgrade teaching quality (Gomez & Ordóñez, 2016). In this regard, the Internet tools can, if used correctly, enhance the learning process and bring significant learning benefits. Therefore, teachers need to be familiar with these tools to use them in their classrooms (Tzimopoulos & Porpoda, 2009). To do this, teachers need ongoing support for the use of ICT in teaching practice, given the rapid technological development and the constant emergence of new tools. Therefore, it is necessary to have structures to provide the practice teacher's permanent support (Cochrane, 2014). One suggestion in this direction is the practice communities, which can function as virtual communities via the Internet.

The virtual community of practice consists of a group of people who work together and support each other to achieve a common goal. Community members communicate and share practices, beliefs, experiences, knowledge, problems, and interests. Wenger (1998) argues that "practice communities are everywhere" and cites the example of family, neighborhood, informal group workplaces, leisure, clubs, and societies. He goes on to explain that practice communities are essential to learning, saying: "... commitment to social practice is the fundamental process by which we learn and become what we are". He also believes that creating a Community includes mutual commitment, requirements, and rules on interaction, responsibility, negotiation concepts, and understanding and learning through the Community practice process.

1.2 Educational robotics

Education is called to qualify students for the knowledge that will enable them to proceed from the simple consumption and use of technological products to their critical analysis, even giving their technological solutions (Kalogiannakis et al., 2021). In this context, there is a growing interest in small programmable devices that can be used to teach computational thinking and problem solving (Papadakis et al., 2021). Educational robotics is the computing environment consisting of one or more robots (either standalone or computer-assisted) that encourage students to think better about a problem and work together. It helps learners acquire knowledge, critical thinking, and familiarity with computers. Besides, the robots take the student out of the computer screen's narrow confines in the real world. Educational robotics (ER) kits or robots in Preschool Education offer a playful and enjoyable experience to young children to engage in STEM activities by constructing robots with or without software applications using motors, sensors, and various everyday materials (Papadakis et al., 2021a; 2021b).

The ICT Curriculum in Greece proposes programming in both the 5th and 6th grades of primary school, highlighting the importance of Informatics and programming in the modern education system. This approach agrees with programming as a critical component for developing information literacy and equating its importance with writing, reading, and mathematics as cornerstones for the individual's cognitive development (Kelleher, 2012). The aim is for students to acquire analytical and synthetic thinking and become familiar with debugging and program optimization techniques to create complex projects themselves, based on simpler parts in a visual programming environment. The recommended visual programming environments are EasyLogo, Scratch, Kodu, MicroWorldsPro, GameMaker, K-Turtle, TurtleArt, openStarlogo, and Educational Robotics. As a pedagogical approach, it fits into classical construction and, in particular, construction, as developed by Papert (Papert, 1991; Resnick, 1994). The main objectives of this approach are:

(1) problem-solving through the handling and construction of real and imaginary objects;

(2) the formalization of thought (using commands in a programming language for automatic operation);

(3) socialization (human cooperation, interaction, and promotion of thought through cognitive and socio-cognitive conflicts);

(4) the acquisition of knowledge and skills related to many disciplines promotes interdisciplinary and interdisciplinary approaches (Kafai & Resnick, 1996).

1.3 An educational model for the implementation of the seminar

Information and communication technology (ICT) is increasingly becoming a more prominent and critical part of students' everyday lives. Consequently, the role of e-learning has transformed completely as recent advances in Information Technology (IT) and the advent of Web 2.0 technologies enabled the creation of learning content that is no longer based on textbooks and learning guides. The traditional idea of "classroom" now incorporates the use of both physical and virtual space (Papadakis et al., 2017; 2018). In non-formal education, we designed and implemented distance seminars for primary and secondary school teachers. The seminars' aim was the pedagogical use of educational robotics and mobile devices in the teaching practice. The biggest challenge in designing the seminars was to overcome the obstacles created by distance education (Kalogiannakis & Papadakis, 2007). We chose distance education, as the action is voluntary and has no resources. In this way, we wanted to include as many teachers as possible from all over Greece. Combining both synchronous and asynchronous remote teaching methods is the most effective adult education model (Ssekakubo et al., 2013). For this reason, the design of the seminars includes communication using the BigBlueButton e-learning platform in addition to the Moodle platform, where the material is published permanently.

We utilized the eTwinning teacher community, which consists of teachers who share common values and ideally support each other in the training process. The seminar consists of weekly lessons, which provide information on the week's topic, the material to be studied, and then activities with which the learner must become familiar with the tools taught. The trainees were divided into 20-30 people (electronic classes), and an instructor undertakes each group. The division into groups is based on the specialty and the place of residence of the trainees. For this action implementation, a community of practice was organized in concentric circles, as follows:

(1) The central management team has responsibilities for the maintenance and management of the training platform, the production and updating of training material, monitoring forums, and the solution of questions and problems. 4 Teachers worked in this group.

(2) A team of trainers' coordinators who coordinate trainers, organize online meetings to discuss problems, monitor trainers' scoring and intervene when needed, follow forums, answer questions, and inform the management team about essential issues. This group employed 18 teachers.

(3) Forums Support Team. These teachers follow the forums and immediately answer any questions that are written in them. Seven teachers worked in this group.

(4) A group of trainers who are teacher-volunteers and have the role of grader and animator and the learning process facilitator. The traditional training model does not apply where the trainers provide ready knowledge and then evaluate its absorption by the trainees. Three hundred forty teachers worked in this group. All participants worked voluntarily.

(5) The trainees of all the seminars were about 7,500 teachers.

1.4 Organization

The action was organized by the National eTwinning Support Service in Greece in collaboration with the Panhellenic School Network, the University of the Aegean, GFOSS, the Hellenic Association for the Development of ICT in education e-Network ICT-E, the University of Peloponnese - Department of Electrical Engineering and Computer Engineering, the Laboratory of advanced learning technologies in lifelong and distance learning (EDIVIA) of the University of Crete, the Laboratory for advanced mobile and educational applications, AETMA, International University and the Laboratory of Teaching Physics and Educational Technology (EDIFET) University.

1.5 The eTwinning project

In recent decades, the importance of information and communication technologies (ICT) has become accepted mainly at all levels of education. The European Union could not remain uninvolved since one of the most significant ICT diffusion steps in education is the eTwinning action. Launched in 2005 as the main action of the European Commission e-Learning Programme, eTwinning has been firmly integrated into Erasmus+, the European Programme for Education, Training, Youth and Sport, since 2014. Objectives of the action include facilitating communication, developing relationships between European schools, and enhancing students' and teachers' abilities in using new technologies, foreign languages, and developing intercultural awareness (Papadakis, 2016).

Under the name 'eTwinning', the European initiative aims to promote new and innovative ways for ICT use in European schools through school twinnings encouraging online collaboration among students and teachers (Gilleran & Kearney, 2014). It aims to promote European teachers' collaboration using ICT. Within the eTwinning community, members share knowledge, good practices and communicate via a diverse set of communication tools, including face-to-face communication and ICT (Grosjean, 2015). Teachers (eTwinners) from pre-school, primary, secondary, and upper schools can all participate in eTwinning to exchange and collaborate, as well as to learn new ICT skills, communication skills, teaching skills, and interdisciplinary working skills (i.e., the 21^{st}-century skills) (Pham et al., 2012). The eTwinning - The Community for European Schools - is a community of teachers from all over Europe, who can participate in various activities, from discussions with colleagues to collaborative projects, while also having the opportunity to participate in a variety of career development opportunities both online and live (Papadakis & Kalogiannakis, 2010). Today eTwinning is the largest network of teachers in the history of education. More than 817,135 people in 208,038 schools have enrolled in it (https://www.etwinning.net). The eTwinning offers significant support to its users. In each of the participating countries (38 currently), a National Support Service (NSS) promotes the action, provides advisory services and guidance to end-users, and organizes many activities at the national level. At the European level, eTwinning is coordinated by the Central Support Office (KYY) under European Schoolnet's direction, a consortium of 31 Ministries of Education.

Many studies have supported the effectiveness of eTwinning in providing authentic learning opportunities through programs and 21st-century skills development (European Commission, 2013; Crawley et al., 2010a). Teachers and students are not limited to the platform's tools but demonstrate skills in using applications that highlight their work, such as digital videos, LMS use such as Moodle, blogs, Web 2.0 tools, and wikis (Kampylis et al., 2013). ICT is used to create exciting courses, overcoming the classroom's limitations and the curriculum. In Greece are registered and participate:

(1) 9,200 Greek schools

(2) 29,500 Greek teachers
(3) 17,500 collaborations from Greek schools

2 Methods

2.1 Educational Material Design

Learners who attend a seminar remotely depend much more on the educational material than the students of a traditional form of education, as there are no face-to-face meetings with the instructor. The educational material was created in such a way that (Kokkos, 2004):
(1) guides the learner in his study.
(2) Promotes the learner's interaction with the material and activities.
(3) Explains difficult points and concepts.
(4) Evaluates and informs the learner about his / her progress.
(5) Encourages the learner to continue.
(6) Allows the learner to freely choose the place and time as well as the pace of his study.

When designing the training material, we considered the trainees' knowledge about using a computer, the time available for the trainees, the ease of communication with the trainer, and the seminar's voluntary nature.

2.2 Implementation

The online courses focused on educational robotics and mobile devices' pedagogical use to implement collaborative activities in eTwinning projects and their integration into the courses' teaching. The tools and services presented at the seminars were free software. The robotics seminars were implemented in 2 periods. The first period that was the pilot ran the period 2018 - 2019, with three months, and the second period that lasted six months started in October 2019 and lasted until May 2020.

The trainees had access to the seminar material through the Moodle e-learning platform, and the participants were supported through the eTwinning hands-on learning community created using tools such as forums, chat, email, and video conferencing.

The material for a new course was posted each week, and participants were required to submit assignments related to the respective unit. The content of the online courses is co-processed by the whole community through questionnaires.

2.3 Scratch, Arduino, Thymio

There is a long, rich history of attempts and strategies to ease the process of learning to program and make programming engaging and accessible to a broader population. Some of these strategies include a) applying pair-programming and collaborative learning, b) using themes that are attractive to students as a multimedia, game, and/or animation approach, c) using visualized programming to introduce core concepts before more advanced and in-depth courses (Kafai, 2016; Patterson, 2016). As a result, many visualized programming tools have been developed and primarily blocks languages, in which programs are constructed by connecting blocks that resemble puzzle pieces (Grover & Pea, 2013; Guzdial, 2004). These tools have become quite popular in recent years and are increasingly used to introduce novices to programming (Kalogiannakis & Papadakis, 2017a; 2017b). To use educational robotics in school, we chose the Scratch programming environment. Then we have to choose a robot, and we chose for the young students up to 12 years old the Thymio and the older ones the Arduino.

Scratch is an educational programming environment developed by the eponymous project at the MIT Media Lab. It has a graphic programming language that makes programming more accessible to children (from 8 years and up), teenagers, and other beginner programmers. It is a dynamic interpreted visual programming language, and being dynamic allows changes to the code even during program execution. It aims to teach programming concepts to children and teens and create games, videos, and music. The latest Scratch 3.0 has many extensions available, making it easy to interface with robotic systems.

Scratch's innovation lies in the fact that one does not have to type a single line of code to write a program. Language is structured like a puzzle or like LEGO pieces. A user has to drag blocks (pieces of code) and stick them in any way you want in the middle so that the generated script produces the desired action. It is, in essence, a programming environment with which we can make our own interactive stories, our games easily and quickly while at the same time coming in contact with the basic principles of programming. The blocks control the actions of sprites on a canvas. In Scratch, users write programs to manipulate sprites; the default sprite is the Scratch cat. These blocks all have notches, which control flow through statements. Each type of value is represented through a different shape. Scratch has three different types of variables (boolean, number, text). Concepts that are often difficult for novices are easier to understand in Scratch because less is hidden. For example, variables can be made visible, helping the user understand the effect of operations such as clearing or incrementing that variable. Scratch supports parallelism across objects and completely hides the compilation process from the user. The Scratch language is designed in order to prevent the generation of runtime errors altogether. Single-step mode is a feature of Scratch that users can use to step through their code and check for behavioral and logical errors. Tracking various blocks when they are called is also possible by choosing to have the code outlined (Papadakis et al., 2016; 2017).

Developed by the Federal Polytechnic School of Lausanne (EPFL), Thymio is a robot designed to teach children computational thinking through programming. Thymio teaches the basics of robotics to students but can also be used in other subjects, such as helping solve problems or teaching children various subjects. Because Thymio can perform a series of scheduled tasks using 50 ready-to-use kits (such as exploring the five senses, teaching music, subtraction, and addition), many of its functions can be applied to non-STEM lessons. It is also designed to attract as many people as possible, regardless of their interests. Everything has been developed under open-source licenses so that there are no compatibility issues in schools. With Thymio, one can not only get acquainted with the basic concepts and ideas of educational robotics but also program the robot in four programming environments:

(1) Visual Programming (Optical Programming based on icons and the idea of the EVENT pair (event) → ACTION (Action))

(2) Blockly Programming (Scratch-influenced Google BLOCKLY-based programming)

(3) Rat Scratch Programming (Scratch enriched programming)

(4) Text Programming (ASEBA text programming for Thymio)

The Arduino is a microcontroller that includes an ATmega chip. It has inputs and outputs that react based on the programming done and loaded on the chip with the computer's help. The programming language it uses is Wiring, which is relatively easy to write and is available on Linux, MAC, and Windows platforms with GPL license. Arduino is an open-source electronics platform based on easy-to-use hardware and software. The Arduino platform bridges the computing world with the physical world, allowing users to connect simple sensors and output devices to a computer (Desai, 2015). The characteristics that have made the Arduino platform ideal for educational use are the following: a) it is reasonably priced, b) it is easy to use and programming, c) it includes an open-ended and expandable software and hardware platform, and d) despite its short existence, it has already had a large number of integrated projects and libraries.

However, what makes the Arduino even more critical is that the entire circuit board is available under a Creative Commons license, which means that anyone can build their board as they wish. Although tiny (7×5 cm), the possibilities it offers are many. We can use it in robotics applications and automation in general, thus achieving servo, stepper, and DC motor drive, receiving information from various sensors (temperature, humidity, infrared), two-way serial communication between Arduino and PC using programming languages (such as Java and Python), as well as sound reproduction and perception.

2.4 Participants

Nine hundred five teachers attended the pilot program that took place in the school year 2018-19. In this research context, national and international research ethics guidelines will be followed (Petousi & Sifaki, 2020). The following teachers participated in the 2019-20 seminars:

(1) Scratch Programming and Educational Robotics: 667.

(2) Educational robotics with Thymio: 163.

(3) Educational robotics with the Arduino: 505.

Of the teachers who started the seminars, the success rates are 82%. The leakage is too tiny for distance education.

3 Results of the evaluation of the seminar

The evaluation model chosen was the "account model." This term means the evaluation carried out to obtain results and the substantiated criticism concerning the course's value, combined with the program's continuation or extension. The evaluation of the discussions was carried out using a final questionnaire. After the lessons end, the trainees answered a questionnaire, which included closed and open-ended questions. Here are the results. To the question "How do you evaluate the seminar?" a substantial percentage of the trainees expressed their satisfaction. 85.7% evaluate the seminar with a score of 9 and 10. (Figure 1)

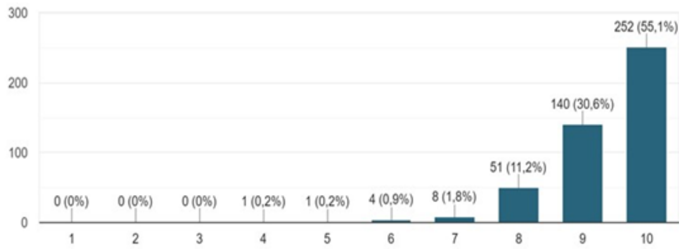

Figure 1 "How do you evaluate the seminar?", 457 answers, Rating scale: 1 (Not at all satisfactory) - 10 (Very satisfactory)

We asked the trainees to tell us how many hours they usually spent studying and working on the activities. Most (67.4%) answered that they worked 2-3 hours a week. 10.3% one hour and 22.3% more than 3 hours. (Figure 2)

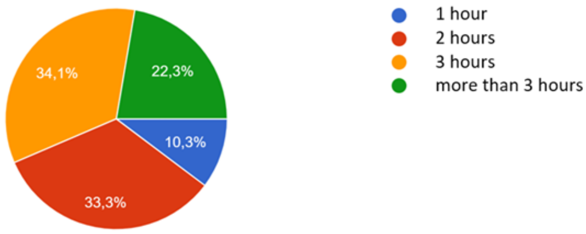

Figure 2 "How many hours do you usually spent studying and working on the seminar activities?", 457 answers.

Regarding communication with the trainer and the other trainees, most (70.7%) used the forum, demonstrating the practice community's dynamics since they could interact with other trainees and seek answers to their questions. (Figure 3)

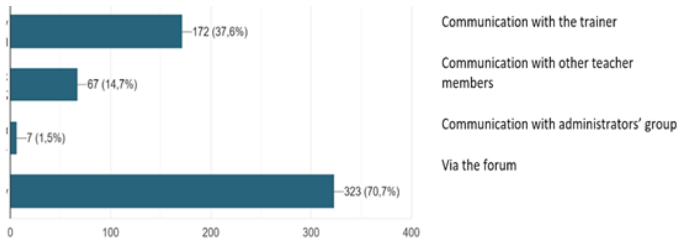

Figure 3 "How did you solve the problems you faced regarding the activities?", 457 answers.

Connections of mutual aid and cooperation were developed, a vital feature of the practice communities as most (56.2%) communicated with each other daily.

Regarding the degree of their satisfaction from the cooperation with their trainer, most of them expressed their complete satisfaction. (Figure 4)

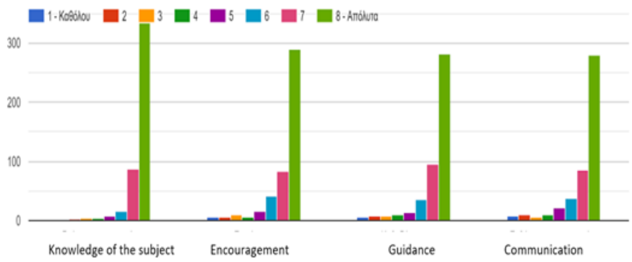

Figure 4 "How do you rate your trainer?" (1 (bad) – 8 (perfect)), 457 answers.

The answers show the degree of satisfaction with how the seminar is conducted to the question "How would you prefer the seminar to take place?". The vast majority (77.7%) answer that they want it to be conducted exclusively through the Moodle platform. (Figure 5)

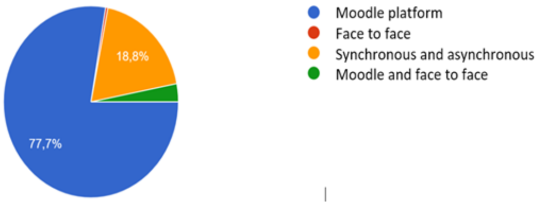

Figure 5 "How would you prefer the seminar to take place?",), 457 answers.

They were also very satisfied with the training material according to the following diagram (Figure 6):

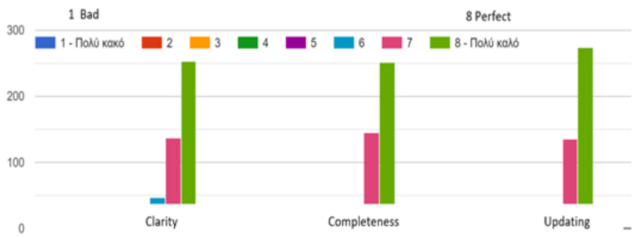

Figure 6 "How do you rate the training material?" (1 (bad) – 8 (perfect)), 457 answers.

When asked if they would use Scratch in teaching practice, 84% answered in the affirmative. (Figure 7)

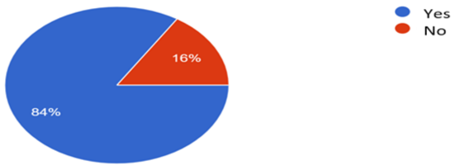

Figure 7 "Are you going to use Scratch in teaching practice?", 457 answers.

To the same question about the Arduino, 81.6% answered that they would use it in teaching. (Figure 8)

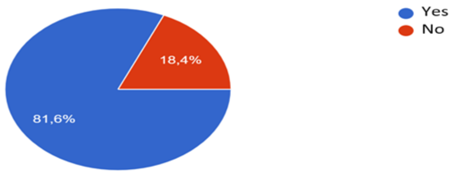

Figure 8 "Are you going to use Arduino in teaching practice?", 457 answers.

Finally, they state that they are pretty satisfied with their knowledge after attending the seminar. (Figure 9)

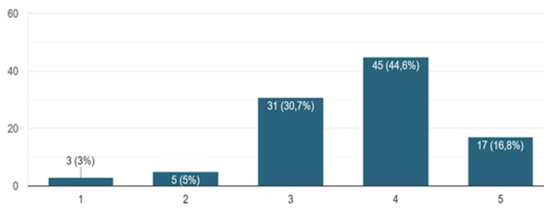

Figure 9 "How satisfied are you with the level of knowledge you acquired attending the seminar?"

4 Conclusions

Incorporating ICT in the educational system should be considered an obligatory modernization of learning and teaching methods. Nowadays, all teachers' retraining is necessary, especially for using the ICT during daily school practice. The use of the ICT is established to bring encouraging results in all levels for the students and their teachers, under the condition that the latter is favorable to the ICT and follow effective and co-operational teaching models (Kalogiannakis & Papadakis, 2019).

As can be seen from the seminars' evaluation, the positive comments, and the teachers' increasing participation, the seminars are considered very successful. They started in this form by PLINET of Syros and expanded, through the eTwinning community, throughout Greece. The methodology of asynchronous distance learning combined with the occasional synchronous distance learning and the structure of the educational material designed in these seminars seems to be widely accepted and meet teachers' training needs. The seminars' implementation was based on the stakeholders' voluntary contribution and operated by making full use of the community of practice's characteristics that give significant benefits to the whole project. For educational robotics, teachers' extensive participation proves the growing community of practice's characteristics, although the topic is that lifelong contact and experimentation with the subject are considered necessary. Distance learning has been very successful, as the seminar evaluation showed. We believe that the Ministry of Education will soon adopt educational robotics in the teaching of courses. This is why we intend to expand the seminars we already implement and create news for other robots such as Edison and BeeBot.

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