Computer Coding at School and Game Creation

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Abstract. Education and schools are facing serious problems to motivate and prepare the new generations. A multidisciplinary educational approach, where students are taught to program, can contribute to a better school. Game creation is a multidisciplinary strategy supported on computer programing that can contribute to set school into the right direction and turn students into effectively active participants on their education. Development and sustainability in a global society are only possible with informed consumers and a good digital task force. Introducing computer programming in European school is a trend and a challenge that is being embraced by several initiatives. This paper emerges from one of those initiatives and describes the strategy adopted to integrate technology in students' curriculum in schools from Portugal, Greece and Italy, through coding and multidisciplinary projects design and development.

Keywords: Coding skills · Game creation · Digital task force
Computer programming

1 Introduction

Technology is evolving at such a pace that digital literacy is a growing issue to be addressed by all sectors of the society [1, 2]. Development and sustainability in this global society is only possible with informed consumers and a good digital task force

A. L. Brooks et al. (Eds.): ArtsIT 2017/DLI 2017, LNICST 229, pp. 458–468, 2018.
https://doi.org/10.1007/978-3-319-76908-0_44

[3]. This means to prepare young students for a digital society, for the upcoming digital jobs, to gain the skills and confidence they need to use digital technology, not only to support their learning but also in their future workplace and so on [3]. In this social economic environment, coding represents one of the key competences that must be acquired by all young students in the scope of 21st Century Skills [4, 5]. Coding is the art of telling a computer how to perform complex tasks. Once students know how to code, they can create virtual worlds within the computer where the only limits are their own imagination.

It's important to bridge the gap between students' skills developed at schools and young people skills needed in the working society. At school, the dominant pedagogy remains "chalk and talk" [6]. Schools "kill" students' creativity and they must change to meet students' needs, because schooling time is short and must be recognized as an important phase of students' lives by all the educational stakeholders and mainly by themselves [7]. It's almost common sense that it's time to adopt more active pedagogies. Technology projects are one way to bring students and their enthusiasm back to school [8]. It's important to create a fertile environment for learning, adopting pedagogies and methods, design and technology projects, that embrace interdisciplinary approaches, usually associated to liberal arts such as studio based learning [6].

Technology can be the instigator for the revolution to happen in education, just as it is doing with several workforces around the world that are being transformed by devices ant the cloud. But, we can't forget that technology at school is just a tool, to truly benefit of digital transformation, schools must recognize that students today learn different than the generations before them [9]. Furthermore, technology doesn't need to replace the curriculum, it can enhance it, leading to deeper student engagement and boosting important skills like creativity and collaboration that students will need in tomorrow's workforce [9]. Peachey's insight on this tells it all:

> *Technology can empower the students of today to create the world of tomorrow. The students we equip with digital skills today will work in careers we haven't even thought of yet, and build new technology that we can't even begin to imagine. Educators, parents, and technology companies have a responsibility to provide them with the best education and tools possible to make this future a reality. Technology is the key to helping our students succeed, think creatively, and ultimately create a better world.* [9, np]

Additionally, the concept of Science, Technology, Engineering, the Arts and Mathematics (STEAM) education, is emerging as a model of how boundaries between traditional academic subjects can be removed so that science, technology, engineering, arts and mathematics can be structured into an integrated curriculum [6].

It's important to reinforce that schooling time is short and it is important to make the most of it, preparing students for life. For this to be possible, school must evolve, endorsing pedagogy changes and learning approaches.

In this scenario, problem-based and project based learning approaches can be examples of strategies that encourage students to become more actively engaged in their own learning [3]. They must be given the opportunity to learn by doing, developing projects, using technology, learning to code and even being able to create their own programs and computer games.

Game creation as an educational strategy supported on computer programing or coding and in a multidisciplinary pedagogical approach can contribute to change the way schools are preparing young people for life [10]. Learning to code isn't easy. A few years ago, learning to code included lots of books, some basic online tutorials and a whole lot of experimentation. Last years, many changes have happened, there exist interactive courses, tons of online tutorials and games to practice coding [11]. A game itself probably isn't going to teach someone to program or code. Games make practice fun and it's easy to spend hours reinforcing coding skills without even realizing it. The potential benefits of using games for learning are clear and they can be more successful than teaching traditional approaches [12]. Furthermore, these games can help students to learn curriculum topics but also improve motivation, intellectual openness, work ethic, conscientiousness, and positive self-evaluation [12].

Thus, coding is an emerging globally priority, much remains to be done in Europe, especially concerning the need to promote real initiatives that can support coding activities in schools. Even though the trend to introduce computing and programming at school as a core curriculum subject has been identified, this task hasn't been easy [5]. Some countries have already done so, and many others are intending to. Portugal, Greece and Italy are among the later or trying to consolidate a few lose initiatives.

Besides the will to introduce computing at school, it is important to help teachers developing the competences to teach coding to students, as well as their own coding competences. Junior Code Academy (JCA) is an European project that also aimed to help teachers at this task. The scenario from Portuguese school's partner was the ignition to establish a set of lessons to help teachers teach students from 10 to 15 years old to code. Another Important contribute to help teachers introducing programming in school, pointed out a set of resources, from which Scratch and Massachusetts Institute of Technology (MIT) App Inventor were elected as learning tools to use at JCA [13]. Scratch and MIT App Inventor are both Creative Commons licenses [13].

JCA project mission is to expand the minds of young students (10–15 years old) and provide them with the right set of tools and skills to meet the needs of tomorrow, implementing a learning strategy under the scope of the demands of 21st century key competences, such as logical reasoning and problem solving.

An overview of the methodology used developing JCA project is described next, as well as the preliminary results gathered and analyzed till now, since this is an ongoing research yet.

2 Methodology

The ongoing project lies down on a design research methodology. Globally, the project intended to design and test a strategy for introducing coding at school, for students between 10 to 15 years old, in the European countries involved. To achieve this main goal, the project consortium conducted a survey to collect data about the state of art on coding at school, in Portugal, Greece and Italy. Then a pilot guide was created and tested in the Portuguese school partner. From this pilot, a functional set of 10 lessons per school year were defined and materials and resources compiled, for the international implementation at the project partner schools'.

This paper describes the ongoing research and presents the main data collected, so far.

Research methodology was developed into these phases: (A) survey on state of art on coding implementation at each school partner, (B) pilot test at Portuguese school partner and (C) international implementation at the Italian and Greek school partners'.

In this scope, several instruments were constructed, validated by experts and deployed to all the participants intervenient in the study. These instruments included a survey and monitoring tools that were applied to students and teachers during the pilot and international implementation phases. Preliminary results as well as data collected was analyzed and are presented in next sections.

3 Ongoing Research

The preliminary results presented now are organized accordingly to the design research steps previously mentioned: (A) state of art on coding implementation at each school partner; (B) pilot testing, and (C) international implementation.

3.1 State of Art on Coding Implementation at Each School Partner

The survey conducted represents the efforts to identify and analyze the state of art on coding implementation at each partner school in what concerns: (a) Policies in the field, and (b) Contextual needs based on data about available infrastructures, connectivity and equipment.

It was answered mostly by schools' partner project coordinators or headmasters and it was reported that:

(i) *Agrupamento de Escolas de Aveiro* (AEA) - 2449 students, 104 classes, 233 teachers and 62 staff members, and comprises all grades from kindergarten to 12^{th} grade. AEA is a schools' cluster with 7 schools' buildings in a 30 km area;
(ii) *5th Gymnasium (*Junior High School*) of Heraklion* (GH) - 420 students, 18 classes, 41 teachers and no staff members, and comprises the following grades: 7^{th} grade, 8^{th} grade and 9^{th} grade;
(iii) *Scuola Media Statale Dante Alighieri* (DA) - 700 students, 30 classes, about 70 teachers and 8/10 staff members and it comprises the following grades: 6^{th} grade, 7^{th} grade and 8th grade;
(iv) *Istituto D'Istruzione Superiore Secondaria Marco Polo* (MP) - 1500 students, 65 classes, about 110 teachers and 20 staff members and it comprises the following grades: 8^{th} grade, 9^{th} grade, 10^{th} grade, 11^{th} grade and 12^{th} grade.

Information and Communication Technologies (ICT) was reported to already be part of the curriculum at Italian and Greek schools', but not at Portuguese ones. It was indicated that in Portugal there were plans to integrate ICT as part of the curriculum soon, because, and we quote, "the government has projects to implement ICT in the next years".

About computer programming or coding it was reported that it was not part of the curriculum in Portugal and Italy (see Fig. 1) and it was reported to be unknown if there were any plans to integrate it in the Portuguese and Italian schools soon.

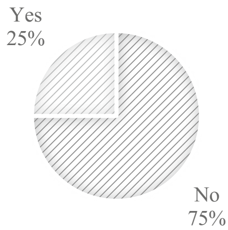


Fig. 1. Computer programming/coding is already part of the curriculum.

The respondent from DA reported computer programming or coding not to be part of the curriculum in Italy, neither to be part of any plans to be integrated in Italian schools soon.

About the contextual needs, it was reported by each school partner that:

(i) AEA - students had access to computers with internet in specific classrooms and library, and that the equipment available in the school were computers and internet. Finally, it was reported that it was unknown if any other equipment would be needed to be acquired for the JCA project.

(ii) GH - students had access to computers with internet in specific classrooms and computer labs, and that the equipment available in the school were computers, internet, printer, scanner and digital camera. Finally, it was reported that it was unknown if any other equipment would be needed to be acquired for the JCA project.

(iii) DA - students had access to computers with internet in specific classrooms, computer labs and library, and that the equipment available in the school were computers, laptops, tablets, internet and printer. Finally, it was reported that it wouldn’t be needed to acquire equipment for the JCA project.

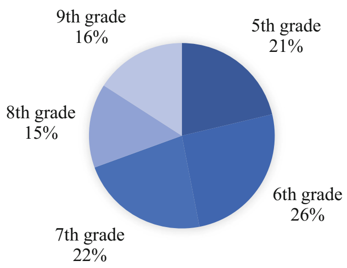
(iv) MP - students had access to computers with internet in computer labs and laptops that students could request, and that the equipment available in the school were computers, laptops, tablets, internet, printer, scanner and digital camera. Finally, it was reported that it might be needed to acquire any other equipment for the JCA project, but it was not identified which.

Globally, the school partners reported that they were at an early stage of adopting strategies to implement computer programming or coding in their schools and JCA project was considered an important step in that process.

3.2 Pilot Phase

The pilot phase consisted on the preparation of a set of lesson plans and its implementation at AEA, in Portugal. Five classes, one per school grade, two teachers and about 130 students, 10 to 15 years old were involved. The pilot was started in the third week of September 2016 and was developed till the end of the first scholar term, December 2016.

The results presented here emerged from the analysis of the monitoring data collected with the tools created for that purpose for both, students and teachers. A total of 1072 responses were collected from students of all the 5 classes along at least 10 lessons (see Fig. 2). And, a total of 53 responses were collect from teachers along at least 10 lessons (see Fig. 4) per class.



Grade	No. responses	%
5th grade	228	21,3%
6th grade	275	25,7%
7th grade	241	22,5%
8th grade	158	14,7%
9th grade	170	15,9%

Fig. 2. Students responses by school grade

Students inquiry and scales used were the following:

(i) Lesson liking (Scale: 1 = not at all to 5 = very much);
(ii) Lessons activities difficulty (Scale: 1 = not at all to 5 = very much);
(iii) Time to finish the activities in each lesson (Scale: 1 = no time to finish to 5 = time to finish all activities); and,
(iv) Global lesson evaluation (Scale: 1 = lesson didn't go well at all to 5 = Lesson did go very well).

Students perceptions indicated that the majority, 67,6% liked the lessons very much, and only 3%, reported that they didn't like the lessons. A great number of students, 38,7% considered that they didn't have difficulties doing the activities. Most of the students, 73% considered that they had enough time to finish the tasks proposed for each lesson. And, globally students' evaluation considered that lessons went well or very well by 88,3% of the students (see Fig. 3).

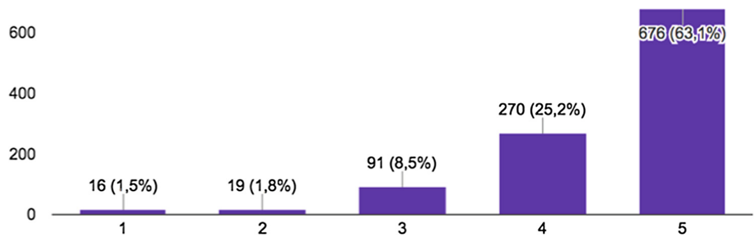
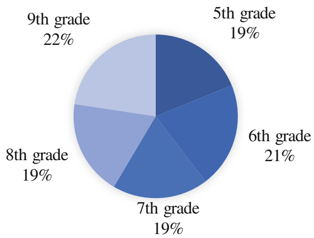


Fig. 3. Students global lessons evaluation (Scale: 1 = the lesson didn't go well at all to 5 = the lesson did go very well)

There were 2 teachers assigned to these classes, but not both were present in lesson at the same time, one was responsible to teach classes from 5th to 7th grade and the other was responsible to teach classes from 8th and 9th grade.



Grade	No. responses	%
5th grade	10	18,9%
6th grade	11	20,8%
7th grade	10	18,9%
8th grade	10	18,9%
9th grade	12	22,6%

Fig. 4. Teachers responses by school grade

Teachers inquiry and scales used were the following:

(i) Lesson plan accomplishment (Scale: 1 = not accomplished to 5 = fully accomplished);
(ii) Activities purposed adjusted to students' capacities (Scale: 1 = not adjusted to 5 = well adjusted);
(iii) Difficulties revealed by most students (Scale: 1 = lots of difficulties to 5 = no difficulties at all);
(iv) Interest revealed by most students doing the activities purposed (Scale: 1 = no interest to 5 = lots of interest);
(v) Enthusiasm revealed by most students doing the activities purposed (Scale: 1 = no enthusiasm to 5 = lots of enthusiasm);
(vi) Contribute of the lessons towards a higher motivation of the students to learn how to program computers (Scale: 1 = nothing to 5 = a lot); and
(vii) Global lessons evaluation (Scale: 1 = the lesson didn't go well at all to 5 = the lesson did go very well).

Teachers reported that most of the lesson plans were fully accomplished, 81,1%, and that they had the perception that the activities purposed were well adjusted to the students' capacities, 77,4%. They also pointed out that most of the students didn't reveal difficulties, 60,4%, or difficulties at all, 39,6%. Teachers considered that almost all students revealed lots of interest doing the activities purposed, 98,1%, and enthusiasm, 96,2%. Finally, teachers indicated that these lessons contributed towards a higher motivation of the students to learn how to program computers.

Globally, teachers considered that lessons went well or very well, 96,2% (see Fig. 5).

Most of the teachers' answers considered that there weren't anomalies to report in the lessons (see Table 1).

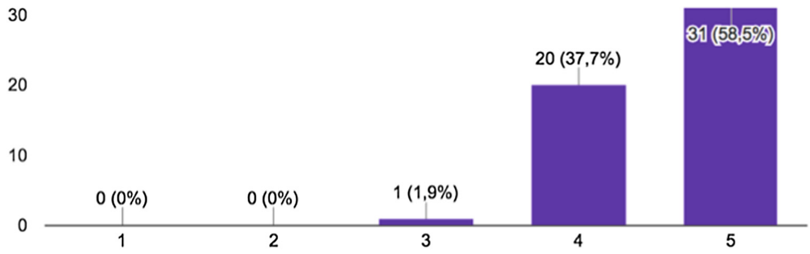


Fig. 5. Teachers global lessons evaluation (Scale: 1 = the lesson didn't go well at all to 5 = the lesson did go very well)

Table 1. Anomalies reported that affected the lessons

Anomalies	No. responses	%
Nothing to report	43	81,1%
No electricity	0	–
No Internet access	0	–
Several computers were or went out of order	0	–
Students arrived late to the lesson	0	–
There were behavioral/discipline issues to report	1	1,9%
Other	10	18,9%

As "other" anomalies teachers reported the following:

- JCA questionnaire complexity (5^{th}, 6^{th} and 7^{th} grade) – reported 3 times, one by school year.
- Students' behavior, they speak too loud (8^{th} grade) – reported 1 time.
- App Inventor is not working or working badly (9^{th} grade) – reported 1 time.
- Noisy students (8^{th} grade) – reported 1 time.
- Slow Internet access, so apps testing time was longer than expected (9^{th} grade) – reported 1 time.
- Noisy students and to many for one class (8^{th} grade) – reported 1 time.
- 45 min were not enough to help and support properly all the students, using a new app. Students revealed low autonomy skills. (8^{th} grade) – reported 1 time.
- To many students in the class to support (8^{th} grade) – reported 1 time.

The pilot monitoring highlighted several issues, such as that students liked coding classes and wanted to learn more. Students were keen on project based learning strategy. These findings were shared with international school project partners and three main suggestions were made:

- lessons should be longer than 45 min;
- classes should have a maximum of 20 students; and,
- lessons would gain if there were at least 2 teachers in the classroom.

These suggestions were adopted accordingly with the possibilities of each school partner, and, besides other variations, all adopted 60 min duration lessons.

Next, preliminary data form Italy and Greek implementations are briefly presented.

3.3 International Implementation

In Greece, the implementation took place at GH, in Crete, Greece. It started in the first week of February 2017 and was developed till the end of May. A 12-lesson plan was implemented.

A total of 292 responses were collected from students. In summary, 38,7% of the students reported that they liked the lessons very much and some students, about 11%, considered that they didn't like the lessons.

When asked about the difficulty of the activities, students reported that they felt that those were not difficult at all, 45,9% and only a few, 7,9%, stated they were very difficult. Many students, 49%, considered that they had enough time to finish all the activities purposed during the lessons and 9,6% considered they didn't. Several students, 35,6% evaluated the lessons globally went very well and 10,6% considered the lessons didn't go well.

A total of 47 responses were collected from teachers, during the same reported period.

Globally, teachers considered that most of the lesson plans have been fully accomplished, 72,3%, and that the purposed activities were adjusted to students' capacities, 76,6%. Teachers also considered that students didn't reveal difficulties doing the activities, 68,1%, and the majority, reported that students did, both, participate with interest and enthusiasm doing the activities purposed, 76,6%. Most teachers also pointed out that the lessons contributed to motivate the students to learn how to program computers, 80,9%. Teachers considered that only a minority of students, 2,1%, revealed difficulties, but that none of them revealed lack of interest or enthusiasm.

Overall teachers considered the lessons went well or very well, 72,3%.

Finally, teachers involved considered that there weren't almost any anomalies to report. However, there were 4,3% reported referrals on behavioral/discipline issues and 6,4% referrals on other anomalies. As "other" anomalies teachers reported the following:

- There was not enough time to complete the lesson – reported twice.
- There was a problem with the Internet.

In Italy, the implementation is still taking place at both schools in Bari, Italy, MP and DA, by the time this paper was written. In Italy, the implementation started later and was not finish yet, nevertheless we could present just a few preliminary results.

A total of 310 responses were collected from students till the 25th of May (103 from MP and 207 from DA). In summary, students liked the lessons very much, 70% and reported that those were not at all difficult, 42% and only a few, 1%, stated they were very difficult. Most students, 62%, considered that they had enough time to finish all the activities purposed during the lessons and 1% considered they didn't. Most of the students, 74%, stated the lessons went very well.

A total of 23 responses were collected from teachers, during the same reported period (7 from MP and 12 from DA). Globally, teachers considered that most of the lesson plans, 96%, have been fully accomplished, and that the activities were adjusted to students' capacities, 95%. Teachers also considered that students didn't reveal difficulties doing the activities, 61%, and the majority, 83%, did both, participate with interest and enthusiasm doing the activities purposed. Teachers, 82%, also considered that the lessons contributed to motivate the students to learn how to program computers. Overall the lessons were going well and very well, 100%.

Data collected so far, allowed us to understand that students were very interested in learning how to code, but that there were some factors, like lesson duration, number of lessons in the plan, number of students per class and number of teachers in the classroom that must be further analyzed.

Final thoughts are presented next as the first conclusions of this ongoing project and research.

4 Main Findings and First Conclusions

The main ideas that emerge from a preliminary data analysis pointed out that 10 lessons to introduce programming at school is the minimum lesson number required. So, we recommend a minimum of 12 lessons, if the school year is organized in terms of about 12 weeks, or between 12 to 15 lessons if the school year is organized in semesters. Classes should ideally have 20 students' maximum. If classes are bigger they should be broken apart in smaller groups for the coding lessons (e.g. 12 students). And, there should be ideally 2 teachers in the classroom, to better support the students work, since project based learning strategy must be the learning methodology to explore.

Even though the research presented here is still an ongoing project, we are aware that more than the impact, that Erasmus + project - Junior Code Academy (JCA): Enhancing coding skills in European schools, might have in the consortium of partners created to develop it and in the students and teachers involved, it is expected that the ongoing research can provide significant data that will allow to better achieve the project goals, namely to help European teachers and schools' leaders to promote the introduction of coding at schools. This paper intends to be a contribution on that way.

Further research and data analysis must be made to enrich the preliminary findings identified. We expect to raise the awareness for the need to prevent some flaws that might influence the introduction of coding at European schools, so they can be minimized. By achieving this, we believe our findings may contribute towards the access and the enhancing of coding skills for all students.

A new school, with interested and enthusiastic students is easier to achieve when they can learn meaningful subjects while participating in project based learning activities and gaming… or even developing their own games, learning to master the basics of game creation. Introducing computer programming or coding at school is a must for European schools and students.

Acknowledgments. With the support of the European Commission, EU Erasmus + Program, under the action type Strategic Partnerships for School Education: "Junior Code Academy – Enhancing Coding Skills in European Schools" (2015-1-PT01-KA201-013121), coordinated by Code for All, Lda.

This article is responsibility of the authors and not from European Commission.

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