Chapter 7
Towards the Development of a Game for Computational Thinking:
Identifying Students' Needs and Interests

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ABSTRACT

Computational thinking (CT) is now considered an essential approach for developing critical thinking and 21st-century skills. CT as a teaching methodological approach is more connected to STEM education as it provides clearer conceptual and practical considerations to understand science, computer, and mathematical concepts. Based on the recent literature, educational robotics, applications, and serious games are the means of applying CT in teaching practice. This study examines students' needs, interests, and motivations for using a game in the context of CT. Quantitative analysis from an online questionnaire to 394 students from secondary education in different five countries (Greece, Cyprus, Italy, Poland, United Kingdom) demonstrate the students' game interests and needs that guide us to develop a game for CT's implementation in the classroom. Essential insights, considerations, and implications are providing for the design, development, and use of games for the CT in an educational environment.

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INTRODUCTION

Nowadays, in the digital society of the 21st century, the exponential onset of computers is forcing a transition in which digital literacy is now a necessary ability to cultivate (Shute, Sun, & Asbell-Clarke, 2017; Angeli & Giannakos, 2020). Most of us use computers regularly and we need to learn how to work with them to get the most out of their computing power (Shute et al., 2017).

It seems that CT is the new literacy. Wing (2006) acknowledged CT as a vital skill cultivated by all literate people attending compulsory education to supplement the other three key competencies: reading, writing, and mathematical skills. Since then, several research studies have been published and many scientific discussions among scholars have been started on how CT can be integrated into the school practice. CT is considered as a thinking process (or otherwise a human thinking ability) that uses analytical and algorithmic methods to formulate, evaluate and solve problems (Bocconi et al, 2016). CT, also, has been advocated by most educational policy makers as a capability that is equally important for all as numeracy and literacy (Bocconi et al, 2016). Not only it is the core for the STEM disciplines and courses (Science, Technology, Engineering and Mathematics), but it is also useful in daily life. The human brain itself is wired to think computationally; therefore, our development and future prospects need to learn how to use its full potential (Henderson, Cortina & Wing, 2007).

In an academic setting, the use of various game tools and educational robotics can be a fun and motivating technique and is recommended to support teaching and learning in the context of CT (Ioannou & Makridou, 2018). Specifically, serious games applications can support teachers' practices providing further understanding and meaningful experiences to students (Anastasiadis, Lampropoulos & Siakas, 2018). As educators continue to unlock their skills, serious and other mobile games, tools or applications are becoming increasingly widespread (Kazimoglu, Kiernan, Bacon, & Mackinnon, 2012). In parallel, students are getting used to gaming in their everyday lives, and technology is even more present around us. Minimizing or eradicating the "digital gap" is vital by promoting more significant involvement in the growing digital environment. Along the same lines, educational robotics is closely related to the CT approach, as it offers to students opportunities to think, develop, construct, communicate, collaborate, and critically reflect on their creations and solutions (Alimisis 2013; Bers, Flannery, Kazakoff, & Sullivan, 2014; Eguchi, 2010).

There are several grey areas in the literature and lots of definitions and explanations, including the definition of CT and mainly how CT can be incorporated into the school curriculum. The use of tools such as robotics posit CT as a very promising area to support learning outcomes at schools (Angeli & Giannakos, 2020). Despite that, different kinds of serious games have been proposed as another way to cultivate students' CT. Based on the existing empirical literature, this chapter aims to provide an important set of considerations regarding the development and the use of robotics and serious games to promote the development of CT in educational contexts. The innovation of this study is the provision of significant conclusions based on secondary education students' perspectives regarding the design and development of a game to be used in the classroom in the context of CT. Educators or researchers could use our findings and conclusions to develop an interesting, meaningful and attractive learning experience applying CT's concepts and approaches.

What follows is first the provision of some theoretical underpinnings, principles, and definitions in CT. After that, the chapter offers an overview of recent empirical studies on the application of games to enhance CT and discusses what the literature demonstrates on the implementation of CT in education. The following section describes the methodology used in this research and presents the most important findings based on the quantitative analysis. Finally, based on the students' responses, the chapter concludes with some important implications for the design, development and use of games for the CT in an educational environment.

COMPUTATIONAL THINKING: DEFINITIONS AND THEORETICAL UNDERPINNINGS

Having as the primary goal to 'foster the 21st century skills necessary to fully participate in the digital world' Bocconi et al., (2016) mentioned that CT is a concept that has been gaining attention recently. Closely linked to coding, programming, algorithmic thinking, CT has been promoted by educational stakeholders along with other skills that are regarded as fundamental for all, such as numeracy and literacy, as well as a means for developing new skills for integration into the employment market (Bocconi et al., 2016), for learning STEM (Weintrop et al., 2014) and for coping with the challenges of the twenty first century (Angeli & Giannakos, 2020). Since it can help youngsters develop skills linked to problem-solving (Henderson, Cortina, & Wing, 2007) and decision-making (Kules, 2016; Wing, 2008), CT has been a subject of attention in studies from various fields in recent years. As a result, CT is a necessary ability for everyone (Hsu, Chang, & Hung, 2018).

In the literature, there is not one current unanimous concept of CT that is being used. Wing (2006) defined the 'computational thinking' as it "*...involves solving problems, designing systems, and understanding human behavior, by drawing on the concepts fundamental to computer science. Computational thinking includes a range of mental tools that reflect the breadth of the field of computer science*" (p.33). Wing, (2006) also, asserted that CT "*represents a universally applicable attitude and skill set everyone, not just computer scientists, would be eager to learn and use*" (p. 33). She also claimed that, "*to reading, writing, and arithmetic, we should add computational thinking to every child's analytical ability*" (Wing, 2006, p. 33). Similarly, Wing (2011), introduced another definition of CT and defined CT as "*the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent*" (p. 1).

Although there is currently no distinct unanimous definition of CT, based on the research literature CT is a thought process that applies some core features (Angeli et al., 2016; Wing, 2006; Barr et al., 2011; Bers et al., 2014; National Research Council, 2010; Selby and Woolard, 2013). The features mutual among researchers are four, namely abstraction, decomposition, algorithmic thinking, and debugging. Table 1 defines the core features of computational thinking.

COMPUTATIONAL THINKING AND STEM EDUCATION

For many educators, CT is a relatively new concept. The goal of CT in education is to teach students how to think like computer scientists so that they can solve problems in a way that a computer might (Shuchi & Roy, 2013). The core features of CT as proposed by many researchers are critical and have a strong link with STEM education and learning because of their connection to the STEM disciplinary processes of modelling, reasoning, and problem solving (Foster, 2006; Henderson, Cortina, Hazzan & Wing et al, 2007; Sengupta et al., 2013).

Table 1. Core features of computational thinking

Feature	Definition
Abstraction	The ability to determine what data to preserve for an entity/object and what to neglect (Wing, 2011).
Decomposition	The ability to break down a complicated problem into easier parts in order to comprehend and solve it (National Research Council, 2010; Wing, 2011).
Algorithmic thinking **a. Sequencing** **b. Flow of control**	The capability to prepare a step by step series of actions to solve a problem (Selby, 2014). The ability to place actions in the right order (Selby, 2014). The sequence in which to perform instructions/actions (Selby, 2014).
Debugging	The ability to recognize, delete, and correct mistakes (Selby, 2014).

In addition, the STEM subjects provide a natural setting for CT instruction (Grover & Pea, 2018) and CT was acknowledged as a core scientific practice by the Next Generation Science Standards (NGSS Lead States, 2013). Through CT-embedded scientific inquiry, the integration of CT for science, technology, engineering, and mathematics (STEM) curriculum has the potential to improve science learning and boost student engagement in STEM learning (Yang, Swanson, Chittoori, & Baek, 2018). By promoting innovation and problem solving, incorporating CT into the classroom helps students prepare for the future (Fessakis, Gouli, & Mavroudi, 2013; Kosmas & Zaphiris, 2019). Computation is an indispensable component of STEM disciplines as they are practiced in the professional world (Jona et al., 2014). As a result, to sustain continuous discovery, thinking skills set among STEM educators and students must be developed (Swaid, 2015). Thus, research needs to focus on CT in STEM education (Tang, Yin, Lin, Hadad, & Zhai, 2020). The question that research in STEM education needs to answer is not why we must integrate CT, but how. As a result, it's vital to look for effective ways to include CT in our STEM teaching.

COMPUTATIONAL THINKING AND EDUCATIONAL ROBOTICS

The research in this field has led to many dialogues and thoughts on the best way to teach CT as learners face many academic difficulties (Bonar & Soloway, 1983; Coull & Duncan, 2011). There is a lot of interest in educational robotics currently, as seen by the constant introduction of new educational robots and articles in the media (Komis, Romero, Depover, & Karsenti, 2019). Naturally, academics have begun to investigate the contribution of educational robotics in promoting CT development (Bers, 2010; Grover & Pea, 2013; Kazakoff, Sullivan, & Bers, 2013; Lee et al., 2011). According to research, children who program robots acquire and apply key CT principles including abstraction, automation, analysis, decomposition, modularization, and iterative design (Bers, 2010, Kazakoff et al., 2013; Lee et al., 2011).

In addition to that, research involving younger children found that children as young as four years old may develop modest robotics projects while learning about important principles in engineering, technology, and computer programming (Bers et al., 2010; Bers et al., 2014). For example, Bers et al., (2014) used Lego WeDo robots and the CHERP (Creative Hybrid Environment for Robotics Programming) language in a study with 53 kindergarten children and found that the children were engaged in the process and understood basic programming and CT concepts relevant to sequencing and selecting the correct instructions. Also, in young children's education, the programming of toy robots (e.g., Bee-Bot) is widely applied (Atmatzidou & Demetriadis, 2016). For this activity, in particular, the learner needs to organize the actions (that wants the robot is to carry out) in a sequence of movements, paying attention to spot similar actions in different situations that can be repeated without re-programming them. Hence, the learner carries out useful practices of abstraction and decomposition. This resonates with the different affordances of physical and virtual environments supporting multiple pathways to CT. Angeli and Valanides (2019) looked at the effects of learning with Bee-Bot, a floor-programmable robot, on the computational thinking of young boys and girls. Because Bee-Bot does not provide a visual representation of the command's children use to program it, scaffolding was expected to play a crucial role in developing children's computational thinking skills when learning with it. The findings displayed CT gains among children.

Studies on the development of CT skills in older children have also yielded promising findings. Recent research by Angeli and Makridou (2018) demonstrated that educational robotics (using the kit LEGO WeDo) was an efficient technique for teaching elementary school students CT skills, even in a short intervention period. What is more, two studies were conducted by Constantinou and Ioannou (2018) at a primary and a secondary school in the Eastern Mediterranean to discuss CT gains of students related to their involvement in educational robotics activities. It was found that students participating in the ER interventions showed substantial development in their CT abilities.

Moreover, a research by Ioannou and Angeli (2016) described the efforts towards designing technology-enhanced instruction (using educational robotics and a 3D interactive programming environment) for teaching Computational and Algorithmic Thinking in 8th graders coming from different secondary education schools in Cyprus. Based on the results, the Technological Pedagogical Content Knowledge framework and the Technology Mapping approach, which guided the design of the instructional intervention, were effective in promoting the development and understanding of computational and algorithmic thinking skills and concepts by students, respectively. Ioannou and Makridou (2018) reviewed published literature explicitly focusing on the use of educational robotics to advance the CT skills of students in K-12. The articles reviewed illustrate empirical evidence indicating that educational robotics can promote students' cognitive and social skills.

However, while robotics appears to be an efficient tool for teaching and learning and a fascinating topic for students of all ages, robotics pedagogy is still in its infancy. Despite the fact that the use of Educational Robotics different kinds of other serious games activities has been proposed as a different way to cultivate students' CT. For example, Bellegarde, Boyaval, and Alvarez (as mentioned in Komis, Romero, Depover, & Karsenti, 2019) give a comparative analysis of cognitive mediations at work in the context of an educational device aimed at introducing robotics and computer science to kindergarten students (5-6 years old). The experimental device is a robot named «Blue Bot,» which features three modalities in the realm of serious games: the body, the robot, and the digital tablet (Komis, Romero, Depover, & Karsenti, 2019).

COMPUTATIONAL THINKING AND SERIOUS GAMES

Screening through limited literature, there was found that games existed long before CT was popularized and labelled as an essential skill. Moreover, games that were once disconnected from schools are now being adopted by teachers as a key teaching tool, while such serious games are incorporated into traditional lesson plans so that students learn concepts through playing (Kazimoglu et al., 2012). This comes as no surprise because computer games contain interactive, engaging and immersive elements that have educational affordances (Frazer, Recio, Gilbert, & Wills, 2014). Most of these games involve a scenario designed to cover a basic programming task and learn algorithmic thinking and help students communicate and collaborate with their classmates, whereas some games address more advanced learning objectives (Malliarakis, Satratzemi, & Xinogalos, 2014). The main idea is to close the gap between theory and practice, merge abstract concepts with practical experiences, and inspire students to learn (Vahldick, Mendes, & Marcelino, 2014).

The concept of 'serious games' has been first introduced by Abt (1970); in his book Serious Games Abt suggested that simulations and games can improve education in the classroom as well as in an informal environment. The definition of the' serious game' has been updated many times since 1970. Sawyer (2002) linked serious games with the connection between a serious purpose and the knowledge and technology now present in the video game industry. Nowadays, there is not one unanimous definition of "serious games". The term is currently established and is becoming increasingly popular. Zyda's (2005, p.26) definition of serious games, stated that entertainment is undoubtedly a component: "*Serious game: a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives*." Zyda (2005) states that serious games supplement pedagogy including activities that teach, thereby transferring information or skills and as a result makes games serious. Additionally, he emphasizes, however, that pedagogy must be secondary to the story and that the entertainment aspect comes first (Zyda, 2005).

The emphasis on the entertainment element contrasts with the definition of serious games proposed by Michael and Chen (2006). Michael and Chen (2006, p.21) defined Serious Games as "*games that do not have entertainment, enjoyment, or fun as their primary purpose*". This definition is consistent with that proposed by, e.g., PIXELearning (PIXELearning.com, 2006); "*The use of computer game and simulation approaches and/or technologies for primarily non-entertainment purposes*". However, Michael and Chen (2006) noted that this is not to suggest that serious games are not amusing, entertaining, or enjoyable, only that there is an added objective over and above the entertainment aspect.

According to more recent literature, Gouin-Vallerand, Ferreira, & Hotte, (2018) created a serious game to provide students with education as a supplement to everyday school learning. A mobile serious game was created and tested with children to introduce ideas in mathematics and English. The findings demonstrated the serious game's usefulness in persuading youngsters to participate in the educational activity and suggested that their understanding had improved. It also highlighted aspects of the game's design. Also, Hart Margheri, Paci, & Sassone, (2020) supported that serious games provide an engaging, enjoyable teaching environment in which participants learn cyber security theory and ideas and put them into practice while playing the game. During the last decade, the importance of using computer video games in secondary and tertiary education has grown significantly, with the dual focus of sharing theoretical and applied knowledge while delivering lessons, as well as offering a means to attract students and maintain their interest in core subjects at the same time (Kazimoglu et al., 2012). Meanwhile, few studies have explored the usefulness of serious games as technological means to enhance computational thinking.

Curricula that used serious games to specialize in learning programming have found positive effects on students as well as on learning outcomes (Ater-Kranov et al., 2010). In their work, "*A serious game for developing computational thinking and learning introductory computer programming*", Kazimoglu et al. (2012), created a serious game, through the use of video game technologies, which promotes the development of CT skills in order to make teaching and learning basic computer programming easier.

The main pedagogical advantages presented to emphasize the fact that 'games are engaging and motivational, thus students will be encouraged to learn programming constructs in an entertaining and potentially familiar environment. Then, students will be able to transfer their learning outcomes from that environment into learning introductory computer programming with a programming language'.

Additionally, a study by Wu and Richards (2011) examined the use of a digital game-based curriculum on the emergence of CT skills in middle school students in Taiwan. Specifically, researchers mentioned that the students would be able to perform the essential abilities of CT (decomposition, pattern recognition, pattern generalization and abstractions, algorithm design, and data visualization) and would demonstrate their ability to apply computational thinking skills to problems that were not within the scope of the game. Also, Cano and colleagues (2021) created a serious game (Perdi-Dogs) for children aged 7 to 11 with hearing impairment. The findings illustrated that children were highly motivated to play.

The most frequently occurring outcomes and impacts seem to be knowledge acquisition/content understanding and affective and motivational outcomes (Basawapatna, Koh, & Repenning, 2010; Combefis, Beresnevičius, & Dagienė, 2016). Moreover, playing serious games to learn programming is linked to a range of perceptual, cognitive, behavioral, affective and motivational impacts and outcomes (Theodoropoulos, Antoniou, & Lepouras, 2017). However, the CT education domain is still in its infancy and requires research for developing theories of the learning mechanisms occurring in computer games (Kazimoglu et al., 2012).

Although for the field of CT education, it is clear that serious games lead to a variety of positive outcomes and impacts; it is also acknowledged that the literature on such games is fragmented and lacks coherence. Hence, the impact of serious games on CT development has only been evaluated to a small extent. It should also be taken into account that CT education is particularly challenging for students underrepresented in computing and engineering, such as girls and other learners from nondominant groups (Eordanidis, Gee, & Carmichael, 2017). For these students, programming learning methods and digital games have been used together in such a way that one benefits from another. Last, although robotics and serious games seem to be different tools or techniques to achieve CT skills, both intend to encourage users to deal with tasks computationally through playing.

DESIGNING A SERIOUS GAME

When creating a serious game for children, it's crucial to think about the aspects of the game that will fulfil their demands. The idea that well-designed digital games can help students learn is supported by research (Prensky, 2001, 2006; Gee, 2007, 2008). According to previous studies, a fundamental issue in serious game design is to strike a balance between learning and fun (Arnab et al., 2015). Klopfer, Osterweil, and Salen (2009) advise that design teams should focus on both learning and game play simultaneously from the start of the design process. The balance between instruction and enjoyment can be achieved by "*connecting the learning goals and skills with the mechanics in a non-superficial way*", and by "*recognizing the minimum requirements to maintain user engagement with a given outcome/objective*" (Dimitriadou et al., 2021, p. 142). In order for the game to be entertaining and deliver "individualized feedback for learners," the games must also be interactive. Educators have voiced a desire to present learners with a simulation of reality within a serious game where they may apply what they've learned. Considerations about the best approach to display content in the game, adapting the numerous game components for the target audience, handling all age groups, having back-up activity options for different students, retaining engagement, and playtesting were among the other design issues (Dimitriadou et al., 2021).

Previous research has identified features of children's cognitive development that should be considered when building tablet applications for them, such as holding only one item in memory at a time (Chang, Tilahun, & Breazeal, 2014) or manifesting concentration, or focusing their attention on only one trait at a time. Other studies have discovered a number of concerns with children with tablets that can be linked to their ongoing development of motor skills, such as difficulty with multi-touch (McKnight & Fitton, 2010), drag and drop interaction (Humphries & McDonald, 2011), not recognized gestures (Anthony, Brown, Nias, & Tate, 2013), and misinterpreting touch movements (Anthony, Brown, Nias, & Tate, 2013; McKnight & Fitton, 2010).

Immediate feedback, a sandbox, customizability, and customizable complexity encourage players to work within their own zone of competency when dealing with the game's issue area (Gee, 2003). It's important to strike a balance between addressing these needs and the game's mechanics. When this balance is not achieved, one of two things can happen: (1) if the challenges are too complex for the individual's skills, the game becomes too difficult, causing anxiety; or (2) if the game is too simple, the player's skills are too far above the game's challenges, the child becomes bored and loses motivation. Furthermore, interaction with tangible objects piques children's interest and can motivate them; yet, digital apps have not yet to be widely adopted in children's learning. Children's social interactions provide a wealth of information for their learning, not just in terms of language but also in terms of behavioral, cognitive, and social dynamics (Cano et al., 2016). CT as a serious game can be a useful tool in the teaching–learning process for children. Designing a serious game necessitates a technique that entails the collaboration of several experts in the subject in order to identify goals that can be applied to the context of use.

METHODOLOGY

The study follows a quantitative approach (Roni, Merga, & Morris, 2020) with the aim to identify the needs and interests of the students in secondary education in order to start working on the designing of a serious game.

An online survey was distributed to secondary students in five countries (Cyprus, Greece, Poland, Italy, UK). Participants were 394 students (N=394) who attended five countries' lower and upper secondary education in the private and public sectors. Namely, 47 students from Cyprus, 39 students from Greece, 190 students from Poland, 98 students from Italy, and 20 students from the United Kingdom. The survey aimed to explore the gaming interests of the students in lower and higher secondary education to use this knowledge to develop an attractive game concept and learning environment in the context of CT.

The educators, through a link, administered the questionnaire to the participants for approximately 10-15 minutes. The questionnaire was created in English and it was translated to Greek, Italian and Polish. The survey included both close-ended and open-ended questions that allowed participants to express their satisfaction on specific aspects of game interests.

First of all, at the beginning of the questionnaire, participants were informed about the aim of the study, issues regarding GDPR and they were asked about their informed consent. After that, they were asked to answer some background information questions, for example, about age, sex and school grade. Then, participants were asked 11 closed ended questions regarding games: 1) if they have played an education game before, 2) if they think that solving problems related to mathematics in a game is important, 3) how much time they spend playing games, 4) why they are playing games, 5) their preferred device, 6) their preferred type of game and 7) setting as well as questions in terms of 8) interaction and 9) comparison with other players, 10) features of games that find most appealing and 11) if they would like to create their own character. To manipulate the game aspects that keep players immersed through the educational content of the game, participants were instructed to rate ten statements about games. For example, "I learn better if I can relate the experiences of an educational game to experiences in real life", on a scale from 1 ('Strongly Agree') to 5 ('Strongly Disagree'). Finally, one open-ended question was used to allow the participants to express their comments, suggestions, and opinions on any other game elements that they would consider important to be included in the game to make it more engaging and attractive.

The survey questionnaire was developed online using the Google Forms software to be able to be administered online. This option works well in terms of saving time as the online software automatically collects the questionnaires and allows visual representation of the data. Also, it offers convenience and easy access to participants as they can fill the questionnaire from everywhere and when they choose according to their own time schedules.

As for the analysis of the results, descriptive analysis was performed in some significant findings regarding the students' responses in the survey (Petscher, Schatschneider, & Compton, 2013).

RESULTS

In this section, we present the main results that emerged from the analysis of the online questionnaire, focusing on data regarding some demographics data, game characteristics and features and students' preferences and interests.

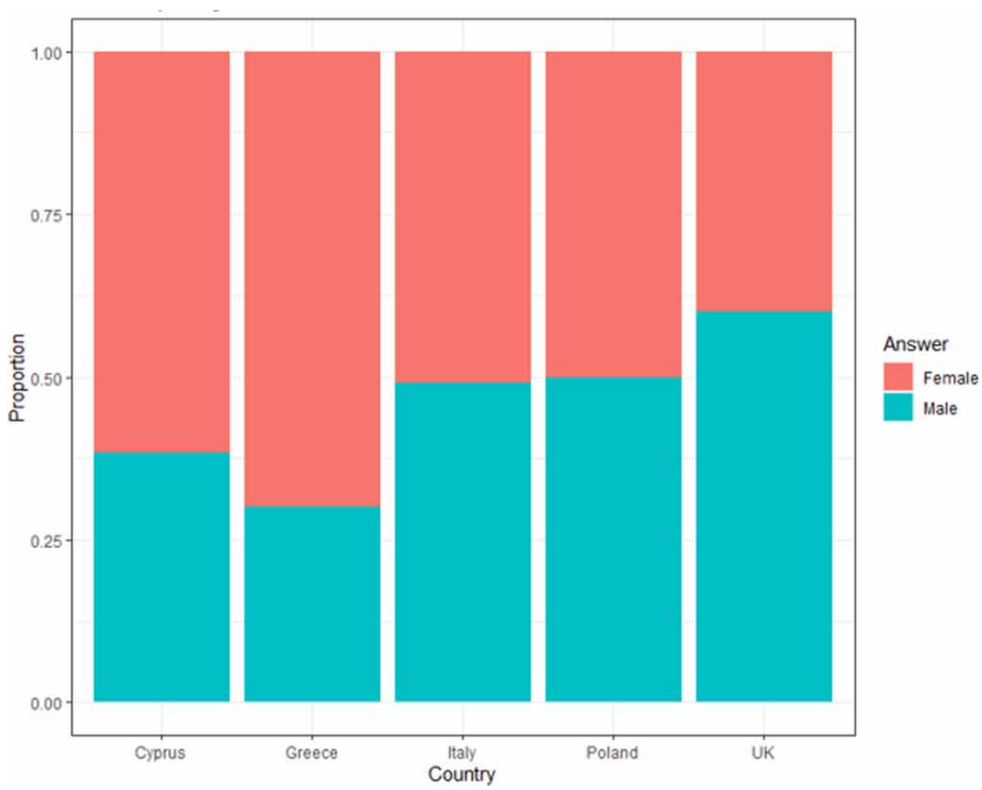
Starting with demographic data, it seems that the majority of students that answered the survey were female. This applies to all countries except the UK, where the majority of students were male. The gender of students that participated in the survey in all countries is shown in figure 1.

Next, the students were asked to report how much time per week they spend online or playing games or using technology devices. A lot of time is spent by children playing, which is as was actually expected. It seems that the majority of the students play games on average for 4 to 6 hours weekly. Specifically, students in the UK spend more time playing games (average time 6 hours) than the other countries that participated in the research. Students from Greece spend less time playing games (average 4 hours), while in Cyprus, Italy, and Poland the average time is 2-4 hours (see figure 2). Of course, that is a positive indicator that we should use learning through playing. Even better we believe that this could be done through hiding learning in the playing. Mobile or serious games is a way to achieve that goal.

In the question "Would you like the fact that you could compare your performance with that of other players?", the majority of students answered yes. From the responses, it is evident that students want their performance to be compared with other players during the game. As we can see in all countries, competition is an element that students prefer during playing (see figure 3). Thus, adding the competition factor in gaming enhances the motivation of students which is key to learning.

In the following question, students shared their opinion regarding the most appealing features in a game. Namely, students had to select among the following features: challenges, clear goal, feedback, graphics, reality, sound, and storyline. The storyline is the most important feature based on students' responses, followed by challenges and graphics. Notably, in Greece and Italy the most appealing feature is the storyline, while in UK and Cyprus the proffered feature is the possibility of playing the game

Figure 1. Participants' gender



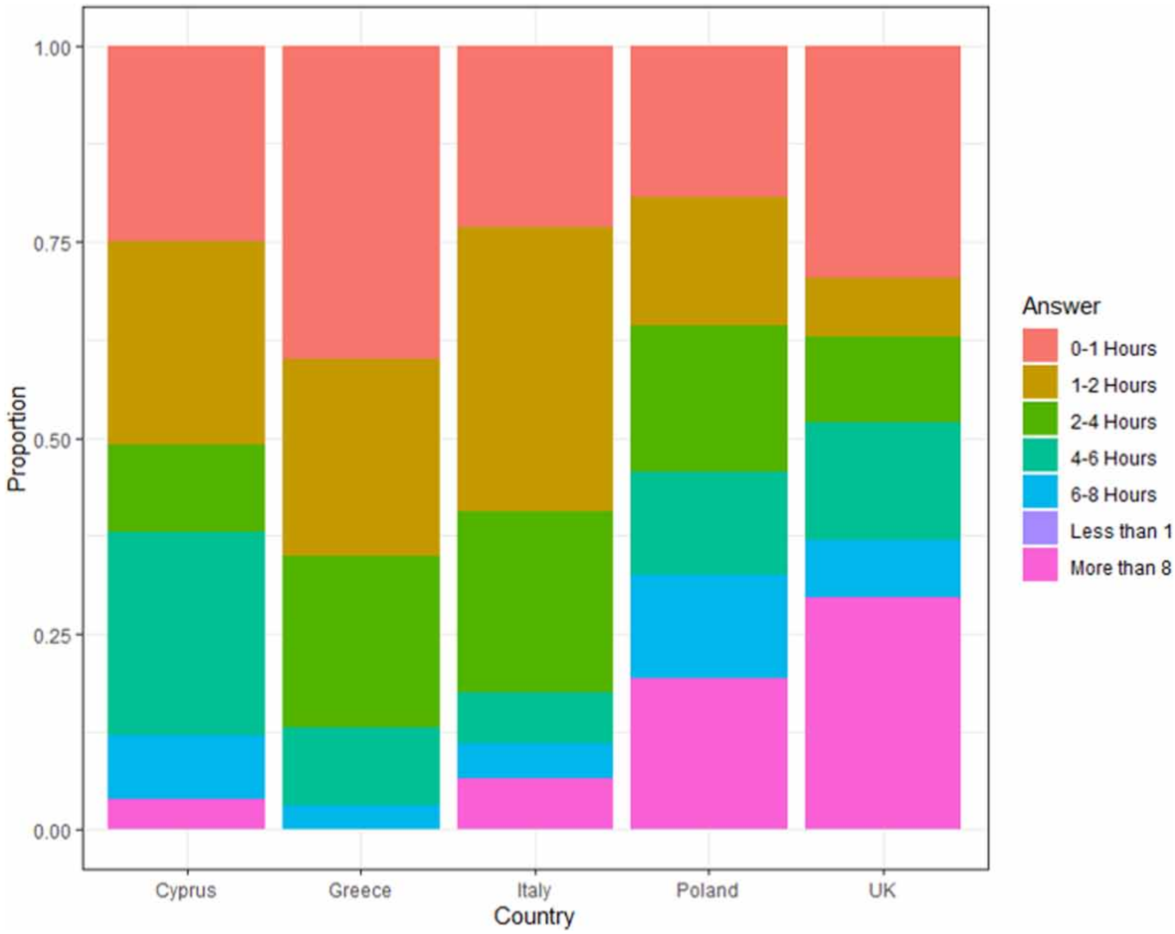
through challenges. One also important feature, according to the students, is the graphics that games have. A less important feature for students is the sound and the clear goal of the game (see figure 4). That's really important for the design and development of the game since the storyline seems to be an excellent feature for all students. Therefore, one consideration for the development is to add a good story in a game since our minds are hardwired to store information in a storytelling format.

In the question "Have you played an educational game before in the classroom?" the majority of students from all countries gave a positive answer. It seems that almost all participating students have previous experience with educational games. Only in Greece and Italy a high percentage of students said no compared to the students from Cyprus, the UK, and Poland (see figure 5). The real challenge when developing a game for learning purposes is to create a really engaging game and create a flow to students and not just presenting educational information in a media format.

As shown in figure 6, the smartphone is the most common answer regarding the preferred device for playing games, followed by PC. Specifically, students from Cyprus, Greece, and Italy preferred to play games using a smartphone, while students from Poland preferred to use a PC. Students from the UK claimed that the preferred device for them is Xbox (see figure 6).

One crucial characteristic/element of such educational games is the possibility to create your own character. As shown in figure 7, it is profound that the vast majority of participating students from all countries, would like to have the option to create their own character while playing a game. Only a small

Figure 2. Time spent per week on playing games



number of students said no. It is undoubtedly a feature that should be added in every online game since the game's personalization is enhanced in that way.

Furthermore, interactivity is one of the most important aspects that we need to consider when designing or developing a game to be used by students in the classroom. Students were asked to answer a question related to whether they prefer a single user or multiplier game. Students' options were three: playing the game alone, two players, more than two players. We report only the responses from students in Cyprus, Italy and UK. According to the responses (see figure 8), the majority prefer a game with multiple players (i.e. two or more players). However, many students still like a single user game (i.e. playing the game alone). It seems that the best option is to provide both single user and multi-user interaction to students to make the game appealing to all.

Last, in the question "what type of setting do you prefer?" students hat to choose whether they prefer an imagination setting or a Real World or both settings. As shown in figure 9, imagination is the most popular answer for all students except for Italian students who prefer real world settings. Almost none of the participating students chose the option for both settings (imagination and real world). Therefore, it seems that imagination with some real-world elements could be the best option when developing a game for students.

Figure 3. Competition during playing

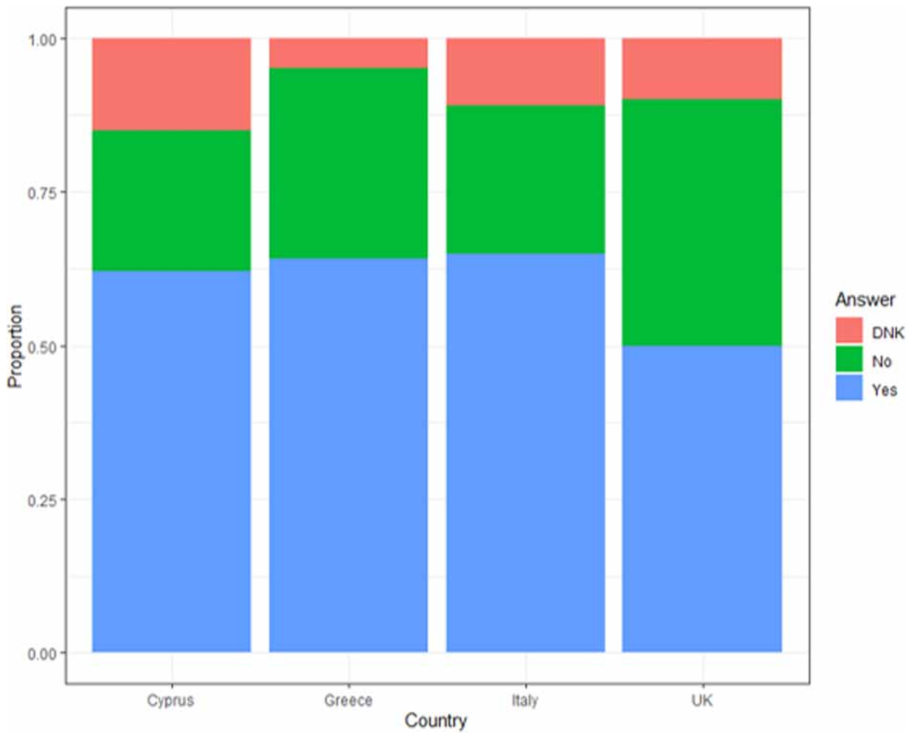


Figure 4. Appealing features in a game according to students

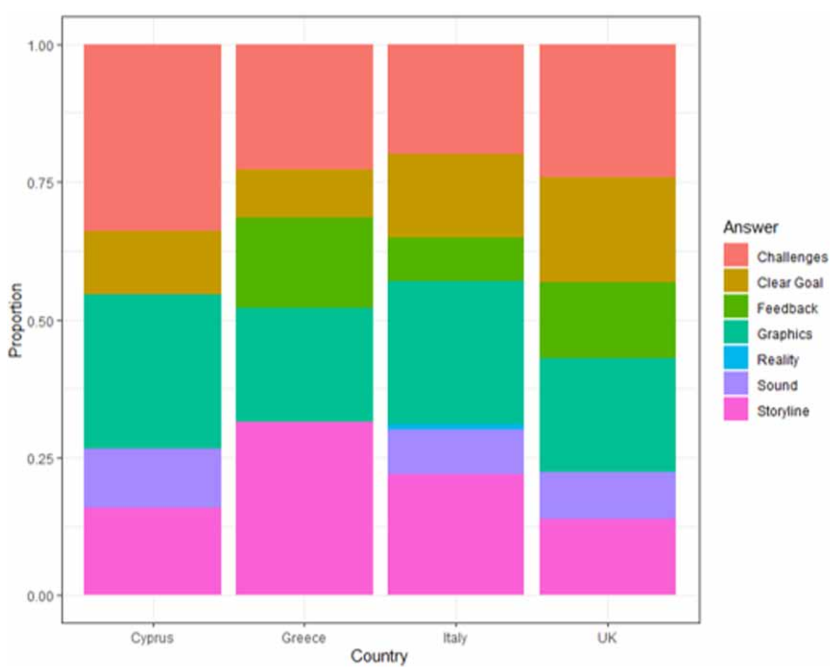


Figure 5. Previous experience with educational games

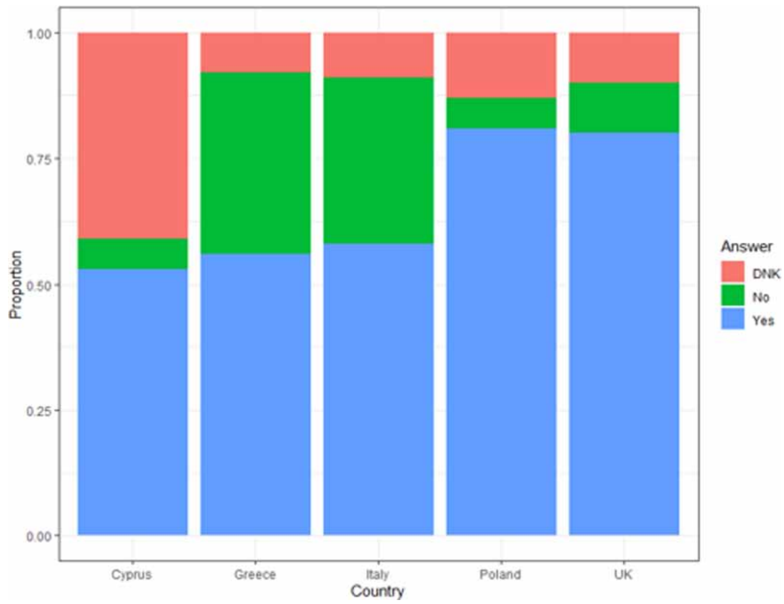


Figure 6. Students preferred devices for playing games

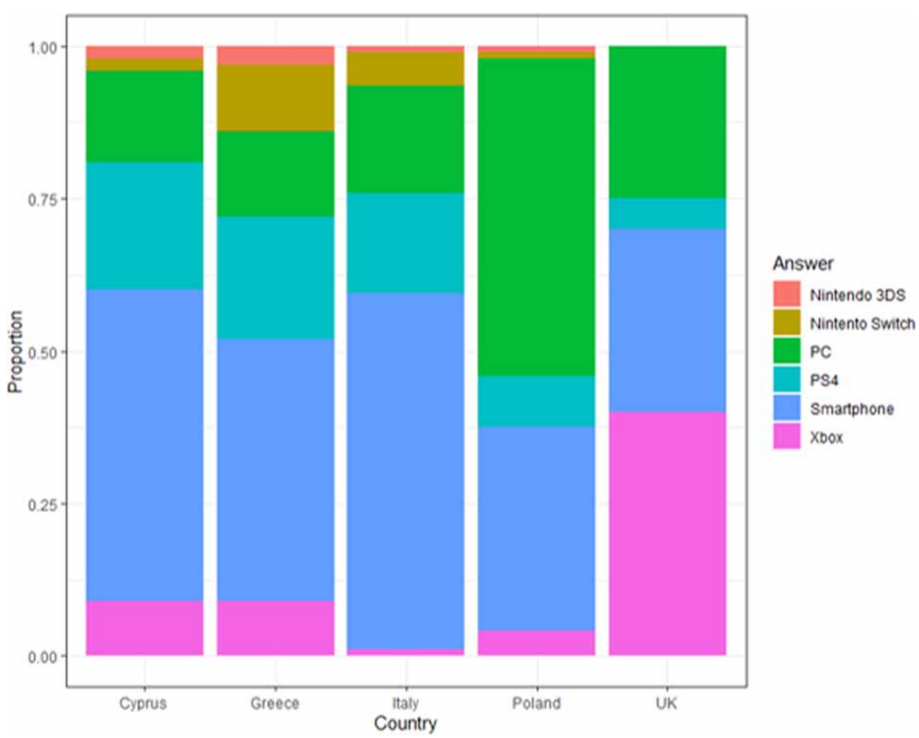


Figure 7. Would you like to create your own character?

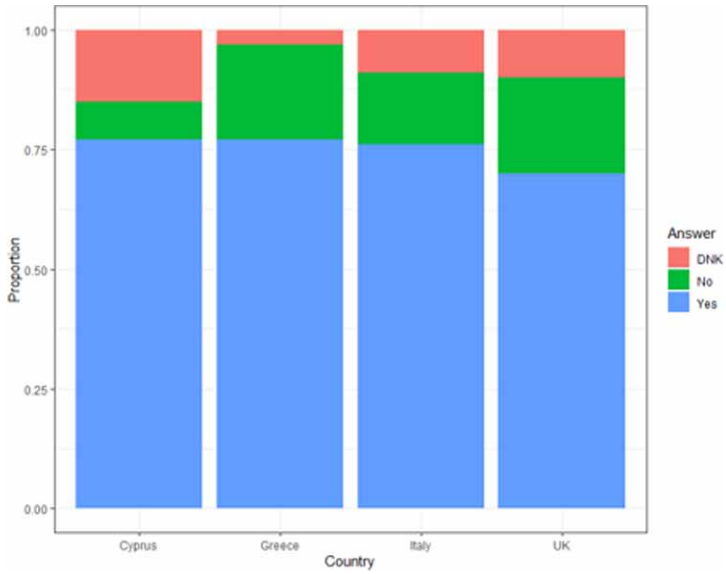
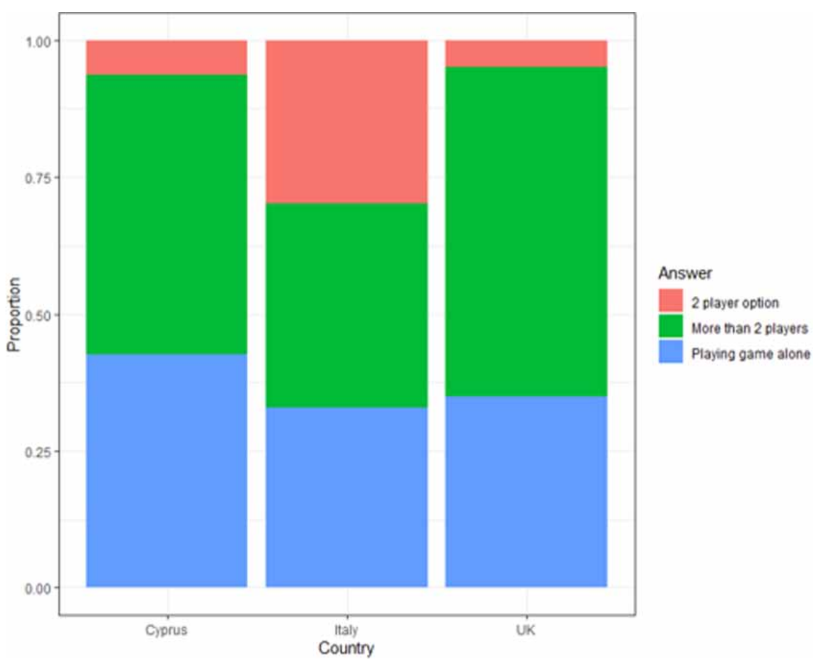


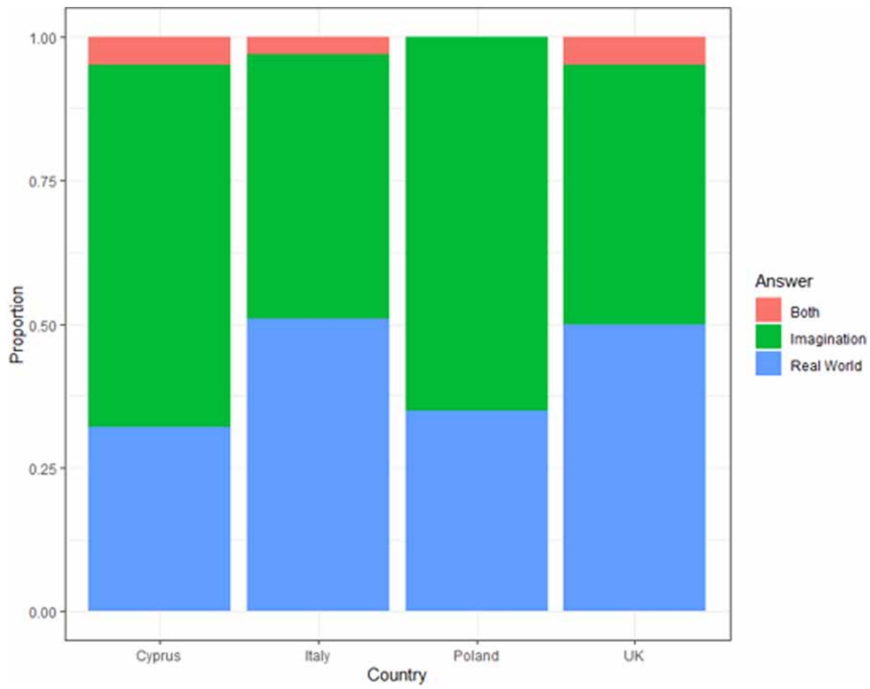
Figure 8. Most preferable interactivity option for students



DISCUSSION

CT in education is emerging worldwide. It seems to be a promise for the education of the new genera-

Figure 9. Type of setting in a game



tion of children. Based on the research many countries are introduced CT or they currently planning to introduce it and/or related concepts into compulsory primary and secondary education and proceed to the curricula reforms.

Moreover, teaching CT may require new pedagogical approaches that put students at the centre of the learning process. The employment of educational robotics and serious games in an educational gaming setting are some techniques advocated to help with teaching and learning. The research was conducted investigating the use of Educational Robotics and CT gains. Specifically, the use of educational robotics is demonstrated by recent research (e.g. Angeli & Valanides, 2019; Angeli & Makridou, 2018; Constantinou & Ioannou, 2018; Ioannou & Angeli, 2016; Ioannou & Makridou, 2018) as an efficient technique for teaching students CT skills. The use of serious games is considered a helpful technique as well. The reasoning behind this is that because games are engaging and motivating, children will be motivated to learn in a fun and possibly familiar setting (Frazer et al, 2014). Furthermore, a curriculum that uses serious games has proven good benefits for students and learning results (Ater-Kranov et al., 2010; Kazimoglu et al.,2012). Serious games seem to contribute effectively to this experience (Gouin-Vallerand et al., 2018; Hart et al., 2020), however more research is needed given that the CT education domain is still in its infancy and requires research for developing theories of the learning mechanisms occurring in computer games.

This chapter conducted a literature review on the role of CT, the role of educational robotics and serious games and the relationship between CT and the state-of-the-art of educational robotics and serious games as a didactical approach for students to learn CT ways and principles. Also, this chapter conducted a field research on students' game interests. Specifically, based on students' responses, a game's specific features and characteristics will make the learning more interesting and engaging for students. This will aim to create a serious game concept that will improve students' CT skills.

Considering everything, it is evident that most of the students have played a game in the classroom before. The majority of students spend playing games on average 4 to 6 hours per week, but a significant percentage of students play more than 8 hours. The majority of the students preferred to use a smartphone to play a game and they prefer to play action, strategy games, sports games, and FSP games in a real-world or imagination setting. In terms of interaction, they prefer to play a game with two or more players, and they would like to compare their performance with that of other players. Most of them they would like to create their own character. The students, also, mentioned that, the most appealing features of the games are challenges, graphics, storyline and clear goal. The majority of them play for pleasure, excitement, competition, challenge, relaxation and leisure.

Additionally, students supported that they learn better if they can relate the experiences of an educational game to experiences in real life and when each new piece of knowledge builds on pre-existing knowledge. Furthermore, they enjoy games that seem too hard and they find feedback on their actions in-game help them to progress. They prefer playing games that have clear goals to achieve. They feel that they learn more when they are engaged in a role they play in a game and they can understand a subject being taught to them if they can experiment with the ideas that are taught. Finally, they are more engaged in games when using knowledge about the game's story and the world to solve problems and if the rewards/bonuses are adjusted to the difficulty of the performance.

Limitations

Although the research has reached its aims, there are some limitations to be addressed in future research. First, our findings are mainly focused on the gaming characteristics that students choose for a serious game, which is a major limitation of this study. Given that the serious game is intended for instructional reasons, additional factors such as students' learning styles may have an impact on their gaming preferences. Future research could gather qualitative data on students' gaming experiences, habits, and interests in order to conduct more extensive analyses and get new insights. On the other hand, obtaining this information is vital and will be the next step for us to fit the game to its educational objective successfully. Also, another limitation of the study is that the questionnaire didn't include topics or questions in relation to STEM or CT. We wanted to create a simple questionnaire for students as a preliminary part of our research. The aim was to examine the students' interests and motivation in playing an educational game in the classroom. Our future intention is to involve teachers in our analysis to see their perspective on the implementation of CT through a game.

FUTURE RESEARCH DIRECTIONS AND IMPLICATIONS

This research provides some important quantitative data regarding the game interests of secondary education students. Future directions involve designing or developing a game by applying all of the above preferences raised by the research participants. Some of the essential considerations when designing a game for CT that need to be taken into account include:

- *Interactivity*. It seems that this is one of the most important features that a serious or mobile game provides. The level of interaction is crucial for the game's success. According to the students, the game must offer opportunities for interaction with other players, but not as a mandatory choice. Players could have the possibility to choose if they want to interact with other players or not.
- *Storyline*. According to students, it is one attractive game feature. Narrative and storytelling attract students' attention and curiosity. Interesting storytelling also motivates students to continue and complete the game to investigate what happened and why. Students can write a story about a topic and act it out with various robots.
- *Challenge-based approach*. A game should have some real-world challenges. During the game students must be faced with a real problem that needs to be solved. This would allow students to critically think, identify the possible alternatives, investigate, and finally propose solutions. The challenges will enable students to gain deep knowledge and develop their skills. The challenge-based approach can be used for designing educational robotics as well.
- *Creativity.* The game should offer possibilities to the students to create or develop something, for example, a character of the game. This is also something that could attract students' interest to play an educational game. Educational Robotics foster students' creativity as it gives the opportunity them to create and develop something.
- *Competition*. Students claimed that it is interesting for them to compete with other players during the game. When a competitive environment is created in a serious game, students' motivation and academic performance improve significantly (Cagiltay, Ozcelik, & Ozcelik, 2015). Robotics Competitions are organized as well in order to increase students' motivation.
- *Educational robotics*. Some numerous games and applications engage students in robotics, teaching them how to code with robotics. Students through the use of robots involved in problem-solving situations and systems thinking. It is now time to consider how a serious game could adopt the logic of robots and provide valuable learning experiences to students. Many characteristics of educational robotics could serve as principles in the development of a game for CT. For example, characteristics such as teamwork, collaboration, problem-solving approaches etc. Could be some basic principles when designing a game in the context of CT.
- *Programming*. The process of producing a set of instructions that inform a computer how to complete a task.

In addition, future endeavors need to be implemented on how educational robotics and serious games could be connected. Although educational robotics and serious games are different techniques to achieve CT gains, both could be considered as methods to achieve 21st century skills through playing. Future studies could explore methods, strategies and approaches on how serious games and robotics can be integrated in the classroom.

Finally, to give a systematic and structured evaluation of the game concept, a set of rigorous experiments needs to be constructed. These will provide analytic data to see if the game successfully supports the development of CT abilities and, as a result, if the game aids students in learning and applying the essential ideas in their lessons. The results need to be analyzed to be able to determine the impact of this game approach and any advantages that can be derived from it.

CONCLUSION

CT has become a buzzword that seems to promise the education of a new generation of children with a much deeper understanding of our digital world. Through the above field research, we looked at the role of CT in education, the relationship between CT and the serious games as a didactical approach for students to learn CT ways and principles. The information collected stresses a clear tendency; the educational landscape is changing fast, and we are now at a tipping point. Various initiatives centered on CT in education are emerging worldwide. Serious games seem to contribute effectively to this experience; however, more research is needed given that the CT education domain is still in its infancy and requires research for developing theories of the learning mechanisms occurring in computer games. We believe that this research offers a clearer understanding of CT in education and provides useful implications for researchers and educators who want to apply CT concepts using games in their practices.

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KEY TERMS AND DEFINITIONS

Algorithmic Thinking: It is a method of solving by clearly defining the procedures required. Instead of coming up with a single solution to a problem, students create algorithms. When followed precisely (by a person or a computer), they are instructions or rules that lead to solutions to the original and related problems.

Coding: It is the process of using programming languages to create instructions for computers.

Computational Thinking: Computational thinking is a collection of problem-solving techniques that describes problems and solutions in a way that a computer can understand.

Digital Literacy: It refers to a person's capacity to find, assess, and clearly transmit information on a variety of digital platforms using typing and other media. It is based on a person's grammar, composition, typing skills, and ability to use technology to create text, images, audio, and designs.

Educational Robotics: Educational robotics, also known as pedagogical robotics, is a discipline that aims to teach children robotics and programming through hands-on activities starting at a young age.

Mobile Games: A mobile game is a video game that is played on a mobile device.

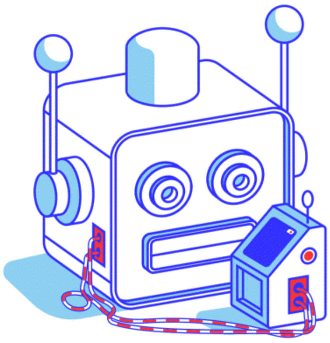
Serious Games: Serious games are games in which their primary goal is to study or practice a skill rather than to have fun.

CTApp: un'App per educare al *problem solving*, divertendo.

Computational Thinking, Serious Games, Internet of Things: espressioni che ormai non sono più solo per gli addetti ai lavori, come chi ha fatto dell'informatica la propria professione. Sia il pensiero computazionale (Computational Thinking) che i Serious Games, sono di fatto approcciati da tutti, non solo perché sono applicati direttamente nei computer, nelle reti di comunicazione, nei sistemi e nelle applicazioni software, ma perché sono strumenti concettuali per affrontare molti tipi di problemi in molte discipline. Una competenza fondamentale che tutti dovrebbero avere, soprattutto quei giovani che vogliono non perdere le opportunità che il futuro presenterà loro davanti, adesso e ancora di più nei prossimi anni. Profetiche sono state le parole dell'ex Presidente degli Stati Uniti, Barack Obama, che durante l'edizione 2013 della Computer Science Education Week, si è rivolto ai giovani dicendo: "**Non comprate un nuovo videogioco: createne uno. Non scaricate l'ultima app: progettatela. Non usate solo il vostro telefono: programmatelo**". Un'ottima sintesi sull'urgenza di utilizzare il pensiero computazionale e i Serious Games come strumenti intellettuali utili a tutti, qualunque sia il proprio lavoro.

In un'epoca in cui la grande quantità di informazioni porta gli utenti a essere facilmente distratti, i corsi di formazione realizzati da aziende, enti o istituzioni rispondono a un'esigenza principale, ovvero quella di rendere la formazione quanto più efficace, veloce e coinvolgente possibile. In quest'ottica si è diffusa la tendenza ad arricchire la formazione con **video, cartoni animati, giochi online e giochi di ruolo**. Tutti questi contenuti multimediali sono utilizzati da utenti di tutte le età per imparare e aggiornarsi in un contesto giocoso e divertente. Così, sia i Millennials che la Generazione Z, appassionati di videogiochi, e i più adulti possono divertirsi e imparare giocando. Dopotutto, imparare giocando è sempre stato uno dei meccanismi più radicati delle persone. Essendo un tipo di apprendimento interattivo, i *Serious Games* consentono al giocatore di **imparare facendo** e di **creare i propri contenuti**. Poichè poi i **Serious Games** hanno lo scopo fondamentale di sviluppare abilità e competenze da applicare nel mondo reale attraverso l'esercizio in un ambiente simulato e protetto, possono diventare metodi **molto utili a scuola e nell'apprendimento**, soprattutto dopo l'esperienza fatta durate il periodo di quarantena causato **dall'emergenza Covid-19**, con la **didattica digitale** che ha assunto un **ruolo fondamentale** nel garantire il diritto allo studio degli alunni.

E' in quest'ottica che è nato il progetto co-finanziato dal Programma ERASMUS+ dell'Unione Europea **CTApp (Computational Thinnking App - *Teaching Students Computational Thinking Through a Mobile Application*** – *2020 - 2023*) (www.ctapp.eu). Lo scopo del progetto è **diffondere l'apprendimento delle Computational Thinking Skills.** Al momento è stata condotta una preliminare analisi dello stato dell'arte (incluso un questionario sui Serious Games e sul Pensiero Computazionale rivolto soprattutto a studenti delle Scuole Superiori - 3° e 4° grado), nei diversi Paesi facenti parte del Progetto (Polonia, Cipro, Grecia, UK e Italia) che ha fornito preziose indicazioni per la progettazione, l'implementazione e la valutazione di un Serious Game per dispositivi mobili. Una volta terminato lo sviluppo del software, verrà eseguita una prova su larga scala in cui saranno coinvolti almeno 200 studenti e verrà osservato il loro successo di apprendimento con il gioco realizzato. A seguito di tale prova il gioco verrà



implementato e finalizzato, pronto per essere disponibile su scala europea, così come l'insieme dei corsi di formazione e dei materiali per gli insegnanti sull'utilizzo del gioco (ad esempio manuali e video didattici).

Se la Commissione Europea ha emanato il *Digital Education Action Plan* (Bruxelles, 2018), con cui ha stabilito alcune priorità nel campo dello sviluppo delle competenze digitali degli studenti e dei cittadini europei, l'**Italia** ha dedicato un intero paragrafo del documento *Indicazioni nazionali e nuovi scenari*, del febbraio 2018, al Pensiero Computazionale: "**Linguaggio e matematica,** correlati, sono alla base del pensiero computazionale [**…**] **. Fondamentalmente, è un'educazione al pensiero logico e analitico finalizzato alla risoluzione dei problemi**. Usandolo in contesti di gioco educativo (es. robotica), dispiega al meglio le sue potenzialità, perché lo studente ne nota subito le molteplici e concrete applicazioni. Ciò contribuisce alla costruzione delle competenze matematiche, scientifiche e tecnologiche, ma anche **allo spirito di iniziativa, nonché all'affinamento delle competenze linguistiche**. Nei contesti attuali, in cui la tecnologia dell'informazione è così pervasiva, la padronanza della codifica e del pensiero computazionale può aiutare le persone a governare le macchine e a capire meglio come funzionano, senza essere invece dominate e schiavizzate in modo acritico. ".

Il Pensiero Computazionale non ha bisogno di tecnologia, viene prima della tecnologia: è una competenza trasversale, un processo di *problem solving* utile in qualsiasi contesto. Per questo merita di essere coltivato e applicato in modo interdisciplinare perché costituisce una sorta di fertilizzante che prepara il terreno sia all'uso consapevole della tecnologia sia alla comprensione degli aspetti logici e della struttura profonda delle attività che si svolgono. La capacità di programmare farà sempre più la differenza tra chi dà ordini alle macchine e chi esegue gli ordini delle macchine e permetterà di rendere concreti i concetti del pensiero computazionale, contribuendo a farlo diventare a sua volta uno strumento di apprendimento, correggendo cosi le cattive impostazioni della scuola tradizionale dove lo studente è oggetto di sistemi educativi che lo rendono spesso un soggetto poco partecipativo. Imparare a programmare consentirà agli alunni di uscire dalla logica di essere solo dei meri utilizzatori potendo diventare loro stessi dei **potenziali sviluppatori**: **CTApp** ha l'obiettivo ambizioso di volersi porre come uno degli **strumenti capaci di contribuire alla formazione delle prossime generazioni**, per renderle sempre più consapevoli del loro incredibile potenziale creativo.

Cristina Fregonese – Innovation Manager per il Progetto CTApp

Serious Gaming & Computational Thinking – An Introduction in the UK

A. Cosmulescu, A. Tokos, G. Boyd

The concept of 'serious games' was first introduced by the researcher Clark C. Abt in his book *Serious Games* (Abt, 1970). Abt proposed the concept that simulations and games can improve education in the classroom. The definition of the 'Serious Game' has been updated many times since 1970. In his white paper Serious Games Initiative , Ben Sawyer linked serious games with the connection between a serious purpose and the knowledge and technology now present in the video game industry (Ahrens, 2015).

In their work, *A serious game for developing computational thinking and learning introductory computer programming*, Kazimoglu et al. put forward the design of an innovative educational game framework focused on the development of Computational Thinking (CT) skills (Kazimoglu et al., 2012). They propose a new strategy to encourage the improvement of teaching and learning of introductory computer programming through the use of video games as a platform to teach and learn from in some cases.

Through this they strive to improve on the education of development of CT skills in children and young people of primary and secondary school age. Developing skill in children to enable them to think in a different perspective such as fostering CT to boost economic growth, fill job vacancies in ICT and prepare for employment.

The National Curriculum in England (Department for Education, 2013) states that '*A high-quality computing education equips pupils to use computational thinking and creativity to understand and change the world.'* They also emphasise that computing has deep connections with mathematics, science and design and technology and provides insights into both natural and artificial systems. The core of computing is computer science, in which pupils are taught the principles of information and computation, how it all works and how to apply this knowledge to use through programming.

However, there is a shortage in fully trained teachers when it comes to the study in computing and therefore in some cases there is only one teacher per school assigned with the task of delivering CT classes. The survey also found that most teachers primarily responsible for CT also teach other subjects, such as business studies and mathematics. These teachers also need support in order to adapt. They require high-quality CPD (continuing Professional Development), therefore training is a must in order to increase their

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knowledge of CT while they also need to acquire experience in teaching the subject.

Although at present 70% of students in England attend schools that offer GCSE computer science, 11% of those students actually enrolled in the school's computer science classes (Department for Education, 2013).

Another issue highlighted by the Royal Society Report (After the reboot: Computing education in UK schools, 2017), are the gender issues in relation to the study and workforce of computing. CT is a male dominated subject throughout the UK. With an uptake of 20% from girls at GCSE, and only a 9% uptake from girls at A level, there is an imbalance that has remained unchanged for several years. The government must work closely together with teaching institutions and employers to find innovative ways to tackle this matter. As part of the progress made, the amount of £2.4 million of government money was allocated to fund for a greater gender balance when it comes to qualifications and study of computing in schools.

As computational thinking aims to create an area where digital technologies and other areas of study such as Arts and Humanities can interconnect effectively, an example of this would showcase one instance with the development of a video game by two UK students aged 13–14 (de Paula et al., 2018). 'Playing Beowulf' was produced in collaboration with the British library and the DARE centre (University College London Institute of Education/Knowledge Lab) in an inner-London school as part of the British Library's Young Researchers programme, using Mission Maker (a software developed at UCL Knowledge Lab). The first-person 3D game was a project funded by the Arts and Humanities Research Council with the aim of promoting *'further engagement with epic Anglo-Saxon poem Beowulf by bringing together a thousand year old text, digital technologies and new means of creative expression.'* This poem was chosen due to its medieval fantasy narrative, quite popular in the video game culture. It should also be noted that this particular concept was chosen because it gives the perfect circumstances for implementing algorithmic loops: the sudden appearance of monsters, the fight starts, rewards are collected by the hero. From a CT perspective, the game showcases several patterns, such as coherent game mechanics and some more complex features in coding, like the use of Boolean Operators (formed from the basis of mathematical sets and database logic).

With this case study, it is shown that CT can successfully be integrated into linking subjects, such as mathematics. ScratchMaths project also provides a good example, developed by University College London and funded by the Educational

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Endowment Foundation, which further explores the way students engage with mathematics through coding ("UCL ScratchMaths", 2021). The project aims to demonstrate that during a CT lesson, students can learn how the brain functions, while learning computer science concepts at the same time.

To support teachers providing CPD classes, a tool guide for teachers is offered by Discovery Education Community who are a global network of teachers and education professionals passionate about enhancing the learning experience of their students ("Discovery Education | Your Daily Learning Platform", 2021). To achieve this, they take the approach of using digital media in order to connect members across the UK and around the world. The main goals of the Discovery Education Community are: to strengthen the way teachers teach and students learn, and to add meaning and relevance to the school curriculum. This in turn helping students and teachers to reach their potential. The Discovery Education Coding focuses on providing support for teaching coding to students in primary schools. This ensuring that pupils acquire a *'secure understanding of coding concepts like algorithms, sequences and variables – as well as developing computational thinking skills the decomposition, logical reasoning and problem-solving'*, this allowing both students and teachers to enhance their creativity through the creation of their own apps and by sharing with peers. Offering: Guided lessons, video tutorials, interactive resources for students, social media support, virtual conferences, and face to face events.

Aspire-igen undertook a survey of 20 UK students aged 12-15 years of age (12 males and 8 females). Overall, students reported that they enjoy playing educational games that include problem solving activities related to mathematics. Just under half of them reported spending more than 8 hours per week playing. In addition to this, most of the participants stated they prefer the games that are challenging and therefore learn more effectively when playing these educational games if they already have some pre-existing knowledge. They also stated that receiving feedback on their actions in-game helps them to progress and understand better. Furthermore, most of the students feel they can understand a subject being taught to them if they can experiment with the ideas that are presented to them and feel more engaged in the games when using prior knowledge about the game's story and world to solve problems as well. Adding onto this, most participants feel they are more engaged in the game if the rewards/bonuses are adjusted to the difficulty of the performance.

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Aspire-igen Group Ltd. For CTApp Project.

Erasmus+ Project number: 2020-1-PL01-KA201-081924

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CTApp Project – Support for Computational Thinking Literacy

Computers help us solve many problems. The presence of computers and computing in our daily life increases exponentially. However, before any problem can be tackled with computing, the problem itself and the ways in which it could be solved need to be understood. Computational thinking (CT) allows us to prepare for just such problem solving.

Computational thinking (CT) is the ability to formulate problems, organize information logically, or think abstractly. The process of computational thinking is usually divided on four main, circular stages:

1. Decomposition of problem by defining manageable questions identifying information needed to solve the problem.
2. Pattern recognition allowing to define problem in symbolic, general, processable and / or computable form, like diagrams, flow charts, algorithms and / or computer code.
3. Processing or computing answers in algorithmic way based on logical rules, identifying and resolving operational issues.
4. Abstracting and generalising results, e.g. in system dynamics models, as well as interpreting and applying solutions to problems to be solved.

The ability to think computationally helps organize basic problem-solving processes and process information into logical sequences aimed at a concrete, practical outcome. The spread of computational thinking (CT) ability can support and accelerate global technological, economic, as well as social development (Papert & Massachusetts Inst. of Tech., 1971; Wing, 2008)

CT is sometimes referred to, as a new dimension of literacy. This skill is advocated by some educators as being as important to everyone as numeracy and literacy (Bocconi et al., 2016; Haseski et al., 2018). CT is not only the foundation for STEM disciplines (science, technology, engineering, and mathematics), but it is also useful in everyday life. CT popularizing can be done without the use of computers (Delal & Oner, 2020). The human brain is designed for computational thinking, so our development and future prospects require learning how to use it to its full potential in each stage of life (Clarke-Midura et al., 2021; Csizmadia et al., 2019; Govind et al., 2020; E. R. de Oliveira Junior & Pasqualotti, 2021; Wang et al., 2021).

In Poland, Computational Thinking was introduced into schools as part of the Computer Sciences and is taught primarily by programming. The second method is by the educational games. In the lower grades CT is taught by the use of the visual programming languages and in the higher grades by textual programming languages. Teaching of CT is included in the Computer Science subject's national curriculum, from the 1 to 8 grade in primary schools and high school's students' (from the age of 7 to 18). In the mathematics curriculum for the grades 6-8, the terms perfecting the abstract thinking and, consequently, learning how to reason and make correct conclusions in new situations, as well as those related to complex and unusual issues, are introduced. It also can be included as part of the CT (Kwiatkowska, 2017).

The goal of the project CTApp is to spread the learning of Computational Thinking Skills. Specifically the project has three aims:

1. Analysis of the state of the art on serious gaming and computational thinking in partner countries.

2. Design, implementation and evaluation of a mobile serious game in computational thinking (CTApp).
3. Development of training courses and materials for teachers on using the CTApp mobile game (e.g. handbooks and instructive videos).

We will train teachers from 5 project countries (PL, IT, CY, UK + GR) into teaching Computational Thinking skills with the CTApp mobile serious game. Trained teachers from each country will train teachers in their own countries through training sessions for primary and secondary schools as well as to Universities. The project contractors are:

- University of Economics and Innovation in Lublin (WSEI), which is a private university established in 2001. WSEI offers bachelor's and master's degree studies in many scientific disciplines. The university has advanced psychological and IT labs and having more than 6,000 students and is a nationally recognised institution that continuously engages in partnerships with EU organisations and institutions to support education, training and research.
- Aspire-igen Group is the largest vocational and training organisation in the Yorkshire region (an area of over 5 million people). The group is a not-for-profit social enterprise with 22 years' experience in supporting young people into employment and has over 150 permanent staff. Aspire-igen Group is a recognised centre of excellence, providing training for careers guidance professionals.
- CARDET is the largest independent not-for-profit research and development centre in Cyprus, with global expertise in entrepreneurship, digital skills and capacity building. CARDET has implemented over 400 projects in the fields of education, entrepreneurship, social inclusion, new technologies, digital skills, working with Yale University, the University of Nicosia and the International Council for Educational Media, among others.
- INNOVA is a private technology and business accelerator, founded in Rome in 1993. It offers incubation and acceleration services for startups and innovative companies working in the field of disruptive technologies in ICT and biotechnology. INNOVA has branches in Italy, Poland (TECH-IN), Spain (INGENIERÍA y INNOVACIÓN), UK (INAVYA) and USA (ICG - Boston). The US company operates within the Cambridge Innovation Centre (MIT Incubator), supporting the creation of new US-EU venture capital scaleup partnerships.
- Innovation Frontiers IKE, is a company that combines game design, game technology, instructional design and psychology to fully master the art of creating educational games, simulations and training. The company implements AI-powered eLearning, resulting in better knowledge transfer, reduced costs, greater transparency of eLearning results, and the ability to provide deeply engaging personal learning experiences for learners.

Projekt CTApp - wsparcie dla umiejętności myślenia obliczeniowego

Komputery pomagają nam rozwiązywać wiele problemów. Obecność komputerów i informatyki w naszym codziennym życiu rośnie wykładniczo. Jednak zanim jakikolwiek problem zostanie rozwiązany za pomocą komputerów, należy zrozumieć sam problem i sposoby jego rozwiązania. Myślenie obliczeniowe pozwala nam przygotować się do takiego właśnie rozwiązywania problemów.

Myślenie obliczeniowe (CT) to zdolność do formułowania problemów, logicznego organizowania informacji lub myślenia abstrakcyjnego. Proces myślenia obliczeniowego dzieli się zazwyczaj na cztery główne, cyrkularne etapy:

1. Dekompozycja problemu poprzez zdefiniowanie przystępnych pytań identyfikujących informacje potrzebne do rozwiązania problemu.
2. Rozpoznawanie wzorców pozwalające na zdefiniowanie problemu w symbolicznej, ogólnej, przetwarzalnej i/lub obliczalnej formie, takiej jak diagramy, schematy blokowe, algorytmy i/lub kod komputerowy.
3. Przetwarzanie lub obliczanie odpowiedzi w sposób algorytmiczny w oparciu o reguły logiczne, identyfikowanie i rozwiązywanie problemów operacyjnych.
4. Abstrahowanie i uogólnianie wyników, np. w modelach dynamiki systemu, jak również interpretowanie i stosowanie rozwiązań do problemów, które mają być rozwiązane.

Zdolność myślenia obliczeniowego pomaga w organizowaniu podstawowych procesów rozwiązywania problemów i przetwarzania informacji w logiczne ciągi, ukierunkowane na konkretny, praktyczny rezultat. Upowszechnienie zdolności myślenia obliczeniowego może wesprzeć i przyspieszyć globalny rozwój technologiczny, ekonomiczny, jak i społeczny (Papert & Massachusetts Inst. of Tech., 1971; Wing, 2008).

CT bywa określane, jako nowy wymiar alfabetyzacji. Umiejętność ta jest postulowana przez część edukatorów jako ważna dla wszystkich w takim samym stopniu, jak umiejętność liczenia i czytania i pisania (Bocconi et al., 2016; Haseski et al., 2018). CT jest nie tylko podstawą dla dyscyplin STEM (nauki ścisłe, technologia, inżynieria i matematyka), ale jest również przydatna w życiu codziennym. Popularyzacja myślenia obliczeniowego może być prowadzona bez stosowania komputerów (Delal & Oner, 2020). Ludzki mózg jest przystosowany do myślenia obliczeniowego, dlatego nasz rozwój i perspektywy na przyszłość wymagają nauki, jak w pełni wykorzystać jego potencjał life w różnych fazach życia (Clarke-Midura et al., 2021; Csizmadia et al., 2019; Govind et al., 2020; E. R. de Oliveira Junior & Pasqualotti, 2021; Wang et al., 2021).

W Polsce myślenie obliczeniowe zostało wprowadzone do szkół w ramach przedmiotu Informatyka i jest nauczane przede wszystkim poprzez programowanie. Drugą metodą są gry edukacyjne. W klasach niższych nauczanie myślenia obliczeniowego odbywa się z wykorzystaniem wizualnych języków programowania, a w klasach wyższych z wykorzystaniem tekstowych języków programowania. Nauczanie myślenia obliczeniowego jest uwzględnione w ogólnopolskim programie nauczania przedmiotu Informatyka, od 1 do 8 klasy w szkołach podstawowych oraz dla uczniów szkół ponadgimnazjalnych (od 7 do 18 roku życia). W programie nauczania matematyki dla klas 6-8 wprowadza się pojęcia doskonalenia myślenia abstrakcyjnego, a co za tym idzie uczenia się rozumowania i wyciągania poprawnych wniosków w sytuacjach nowych, a także dotyczących zagadnień złożonych i nietypowych, co można również włączyć w zakres myślenia obliczeniowego (Kwiatkowska, 2017).

Celem projektu CTApp jest upowszechnienie nauki umiejętności myślenia obliczeniowego. Projekt ma trzy cele:

1. Analiza stanu wiedzy na temat poważnych gier i myślenia obliczeniowego w krajach partnerskich.
2. Zaprojektowanie, wdrożenie i ewaluacja mobilnej poważnej gry w myślenie obliczeniowe (CTApp).
3. Opracowanie kursów szkoleniowych i materiałów dla nauczycieli dotyczących korzystania z mobilnej gry CTApp (np. podręczniki i filmy instruktażowe).

Przeszkolimy nauczycieli z 5 krajów projektu (PL, IT, CY, UK + GR) w zakresie nauczania umiejętności myślenia obliczeniowego za pomocą mobilnej gry CTApp. Przeszkoleni nauczyciele z każdego kraju będą szkolić nauczycieli w swoich krajach w trakcie sesji szkoleniowych dla szkół podstawowych i średnich, a także dla uniwersytetów. Wykonawcy projektu, to:

- Wyższa Szkoła Ekonomii i Innowacji w Lublinie (WSEI), która jest prywatną uczelnią założoną w 2001 roku. WSEI oferuje studia licencjackie i magisterskie w wielu dyscyplinach naukowych. Uczelnia posiada zaawansowane laboratoria psychologiczne i informatyczne oraz kształci ponad 6 000 studentów i jest uznaną w kraju instytucją, która stale angażuje się w partnerstwa z organizacjami i instytucjami UE w celu wspierania edukacji, szkoleń i badań.
- Grupa Aspire-igen jest największą organizacją zawodową i szkoleniową w regionie Yorkshire (obszar zamieszkiwany przez ponad 5 milionów ludzi). Grupa jest przedsiębiorstwem społecznym typu not-for-profit, z 22-letnim doświadczeniem we wspieraniu młodych ludzi w znalezieniu zatrudnienia, mającym ponad 150 stałych pracowników. Grupa Aspire-igen jest uznanym centrum doskonalenia zawodowego, zapewniającym szkolenia dla profesjonalistów z dziedziny doradztwa zawodowego.
- CARDET jest największym niezależnym ośrodkiem badawczo-rozwojowym typu not-for-profit na Cyprze, posiadającym światowe doświadczenie w zakresie przedsiębiorczości, umiejętności cyfrowych i budowania potencjału. CARDET zrealizował ponad 400 projektów z zakresu edukacji, przedsiębiorczości, włączenia społecznego, nowych technologii, umiejętności cyfrowych, współpracując m.in. z Uniwersytet Yale, Uniwersytet w Nikozji i Międzynarodową Radą Mediów Edukacyjnych.
- INNOVA to prywatny akcelerator technologii i biznesu, założony w Rzymie w 1993 roku. Oferuje usługi inkubacji i akceleracji dla startupów i innowacyjnych firm działających w obszarze przełomowych technologii w dziedzinie ICT i biotechnologii. INNOVA posiada oddziały we Włoszech, Polsce (TECH-IN), Hiszpanii (INGENIERÍA y INNOVACIÓN), Wielkiej Brytanii (INAVYA) i USA (ICG - Boston). Spółka amerykańska działa w ramach Cambridge Innovation Centre (MIT Incubator), wspierając tworzenie nowych amerykańsko-unijnych partnerstw typu venture capital scaleup.
- Innovation Frontiers IKE, to firma, która łączy projektowanie gier, technologię gier, projektowanie instruktażowe i psychologię, aby w pełni opanować sztukę tworzenia gier edukacyjnych, symulacji i szkoleń. Firma wdraża eLearning wspierany przez AI, co skutkuje lepszym transferem wiedzy, obniżeniem kosztów, większą przejrzystością wyników eLearningu oraz zdolnością do zapewnienia głęboko angażujących osobistych doświadczeń edukacyjnych dla słuchaczy.

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CtApp

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WHAT IS CtApp?

The project (which runs 2020-2023) aims to spread the learning of Computational Thinking Skills through the development of a State of the Art on Serious Gaming & Computational Thinking, the Design, Implementation and Evaluation of a Mobile Serious Game in Computational Thinking and implementing Teacher Training Courses and Materials development on using the CtApp mobile game - handbooks and instructive videos.

WHY CtApp?

Computational Thinking (CT) is a thought process that uses analytic and algorithmic approaches to formulate, analyse and solve problems. In recent years, CT has also been promoted by most educational stakeholders as a skill that is as fundamental for all as numeracy and literacy and is considered a universal competence, which should be added to every child's analytical ability as a vital ingredient of their school learning.

SERIOUS GAME EVALUATION

Once the software development is finished, we will run a large-scale trial in which we will involve at least 200 students and observe their learning success with our mobile game. We will then finalise our mobile game and share it on an EU-wide scale.

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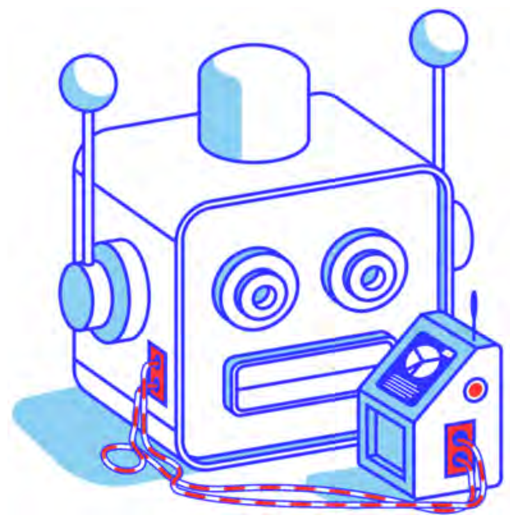
“Don't buy a new video game: make one. Do not download the latest app: draw it. Don't just use your telephone: program it ". Barack Obama 2013

THE CT SITUATION IN THE UK

Paving the way to curricula reforms within Europe, the UK was one of the first EU countries to introduce CT and coding in the national curriculum for primary and secondary schools in September 2014, stressing not only the importance of computation and programming, but of conceptualising CT as well.



The 2012 study published by the Royal Society, “Shut down or restart? The way forward for computing in UK schools” – a review of computing education in the UK”, concluded that ICT is too technological, and it should be re-defined into clearer areas. Therefore, ICT was removed from the national curriculum and replaced by Computing, covering all three strands of: digital literacy, information technology and computer science. Becoming mandatory for pupils aged 5-16 years in England, Computer Science and CT became part of the foundation subjects in England, together with English, Mathematics and the Sciences.

Find out more at: https://ctapp.eu/

For more information on CtApp in the UK:
ana.tokos@theopportunitycentre.com