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Towards the development of a game for Computational Thinking: Identifying the 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. 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 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.

Keywords: Computational Thinking, Robotics, serious games, students, classroom, secondary education

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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). Most of us use computers on a regular basis and we need to learn how to work with them to get the most out of their computing power (Shute et al., 2017). This is called Computational Thinking (CT).

It seems that CT is the new literacy. Wing (2006) acknowledged CT as a vital skill that should be cultivated by all literate people attending compulsory education to supplement the other three key competencies which are 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).

The use of different game tools and educational robotics in an academic environment, could be only one enjoyable and motivational method that is suggested to support the instruction 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 being even more present around us. It is vital to minimise or eradicate the "digital gap" by promoting more significant involvement in the growing digital environment. Along the same lines, educational robotics is close interlinked with the CT approach, as it offers to the students opportunities for 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, including the definition of CT and mainly the way that CT can be incorporated into the school curriculum. Based on the existing empirical literature, this chapter aims to provide an important set of considerations regarding the development and the use of games for 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

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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. 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). 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 a variety of fields in recent years. As a result, CT is a necessary ability for everyone.

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 behaviour, 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; NRC, 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.

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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 recognise, delete, and correct mistakes (Selby, 2014).

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 emphasized in CT are critical for STEM learning because of their connection to the STEM disciplinary processes of modelling, reasoning, and problem solving (Sengupta et al., 2013). The features of CT as proposed by many researchers have a strong link with STEM education. STEM education emphasized the integration of classroom learning with real-world situations. Furthermore, because computational use in STEM disciplines is high in these subjects, CT is critical for STEM education (Foster, 2006; Henderson, Cortina, Hazzan & Wing et al, 2007).

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). 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, there is a need for research that focuses on CT in STEM education. 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.

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Computational Thinking and educational robotics

The research in this field has led to many dialogs and thoughts on the best way to teach CT as learners face many academic difficulties (Bonar & Soloway, 1983; Coull & Duncan, 2011). Naturally, academics have begun to investigate the promise 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 split the actions (that wants the robot is to carry out) in a sequence of movement, 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.

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 period of intervention. 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

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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 use of Educational Robotics different kinds of other serious games activities have been proposed as a different way to cultivate students' CT.

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 cover more advanced learning objectives (Malliarakis, Satratzemi, & Xinogalos, 2014). The main idea is to shorten the time between theory and practice and merge abstract concepts with practical experiences and, therefore to 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 supplements 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 comes in contrast 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

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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 that. The main significance is the precision of the process or effect being stimulated for training.

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), put forward the design of an innovative educational game framework focused on the development of CT skills, a serious game, which encourages the development of CT skills to facilitate learning introductory computer programming. They proposed a new strategy in order to facilitate the teaching and learning of introductory computer programming through the use of video game technologies in an educational game context, also referred to as 'serious games'. The main pedagogical advantages presented underline the fact that 'games are engaging and motivational, (thus) students will be encouraged to learn programming constructs in an entertaining and potentially familiar environment, and will then be able to transfer their learning outcomes from that environment into learning introductory computer programming with a programming language'. In addition, where serious games have been introduced as part of the curricula specialising in learning programming, there have been positive effects on students as well as on learning outcomes.

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

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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 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.

Designing a serious game

When creating a serious game for children, it's crucial to think about the aspects of the game that will fulfill their demands. The idea that well-designed digital games can help students learn is supported by research (Prensky, 2001, 2006; Gee, 2007, 2008). 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 with the aim to identify the needs and interests of the students in secondary education. An online survey distributed in 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.

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 environment. The survey included both close-ended and open-ended questions that allowed participants to express their satisfaction on specific aspects of

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game interests. 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 performs the collection of 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. Some important findings regarding the answers of the students in the survey are shown in the charts below.

RESULTS

As mentioned earlier, the aim of the questionnaire was to address the game interests of secondary students. 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. In total, 394 students from five countries responded to the survey. Namely, 47 students from Cyprus, 39 students from Greece, 190 students from Poland, 98 students from Italy, and 20 students from United Kingdom. In figure 1 the gender of students that participated in the survey in all countries is shown. In most countries (except for UK) the majority of students that answered the survey were female.

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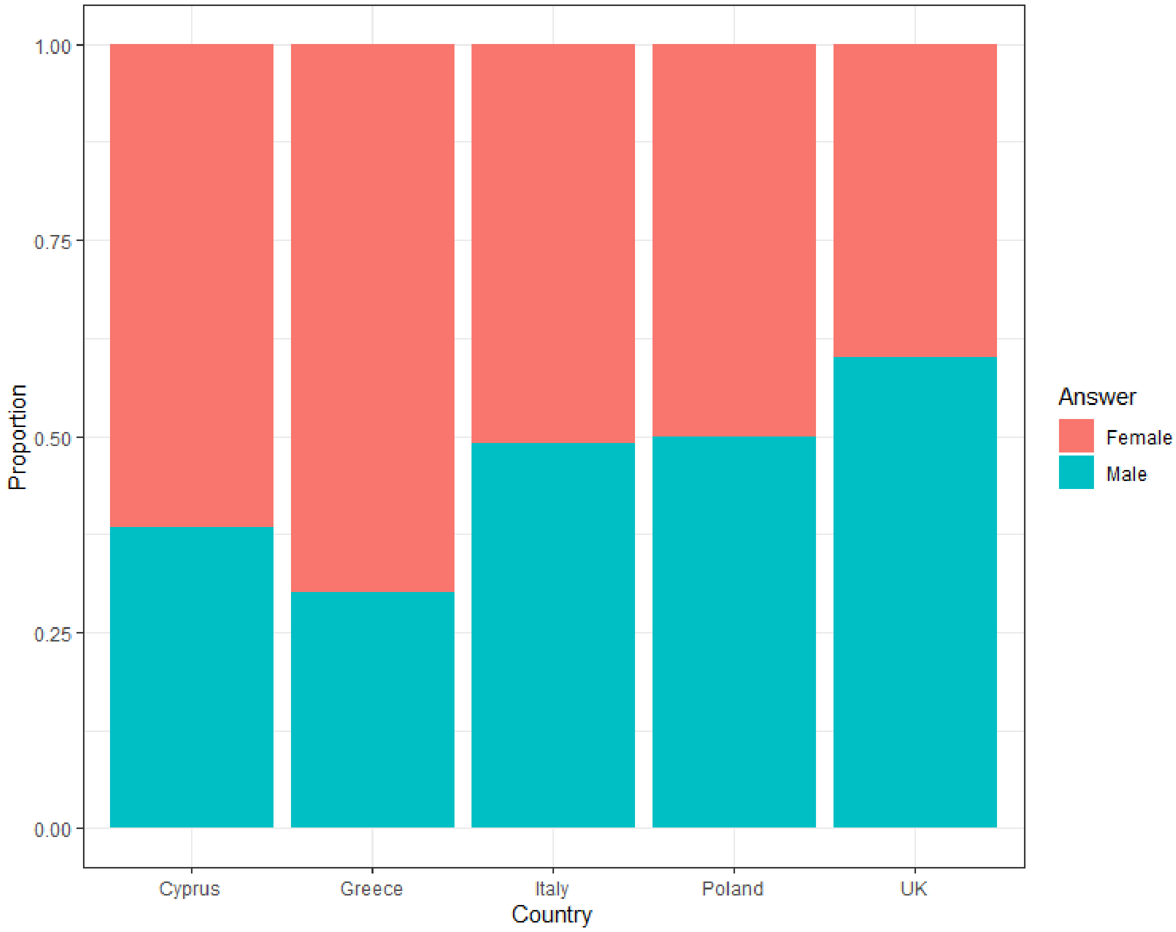

Figure 1. Participants' gender

In the following figure 2, the time on average that children are spending is displayed. A lot of time is spent by children playing which is as was actually expected. 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.

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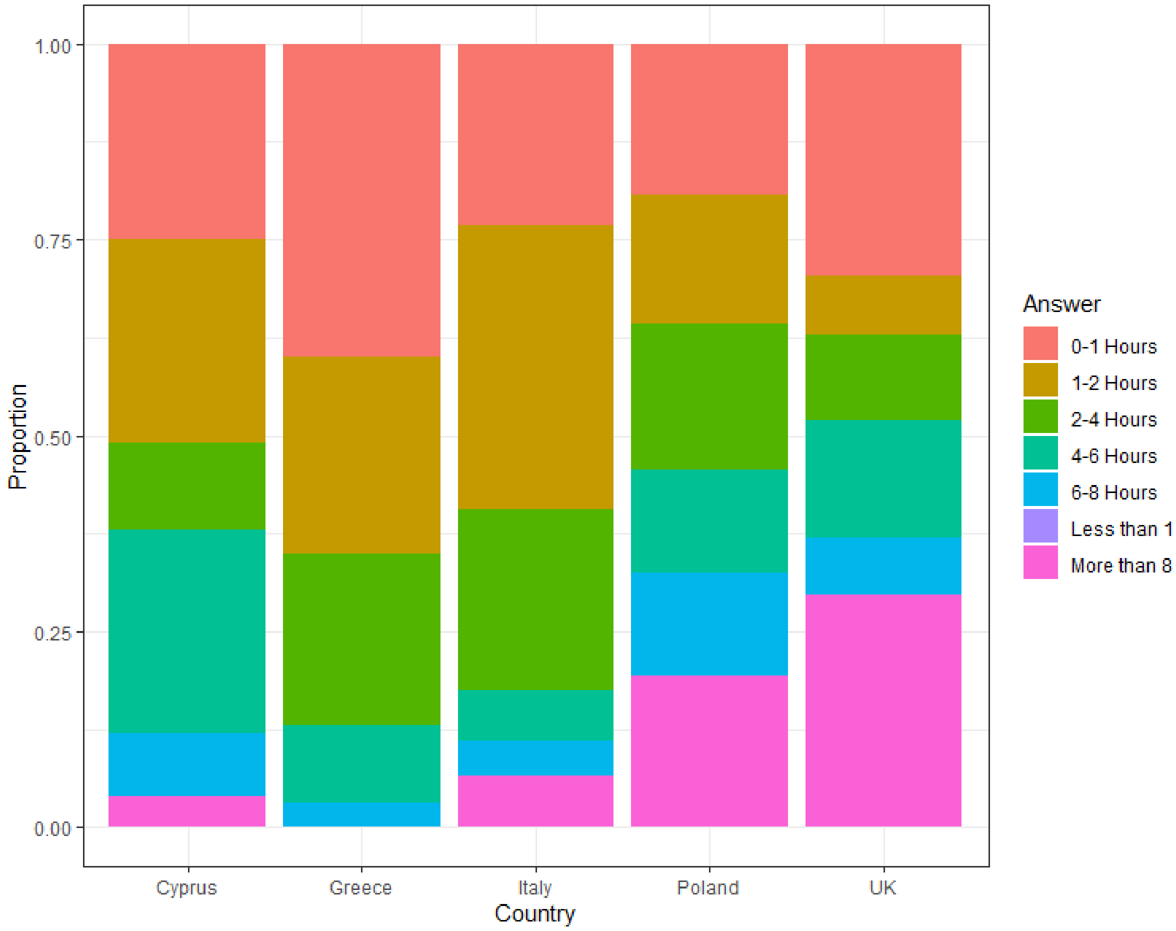

Figure 2. Time spent per week on playing games

In figure 3 we can see answers related to whether students want their performance to be compared with other players. As we can see in all countries competition is an element that students prefer during playing. Thus, adding the competition factor in gaming is enhancing the motivation of students which is key to learning.

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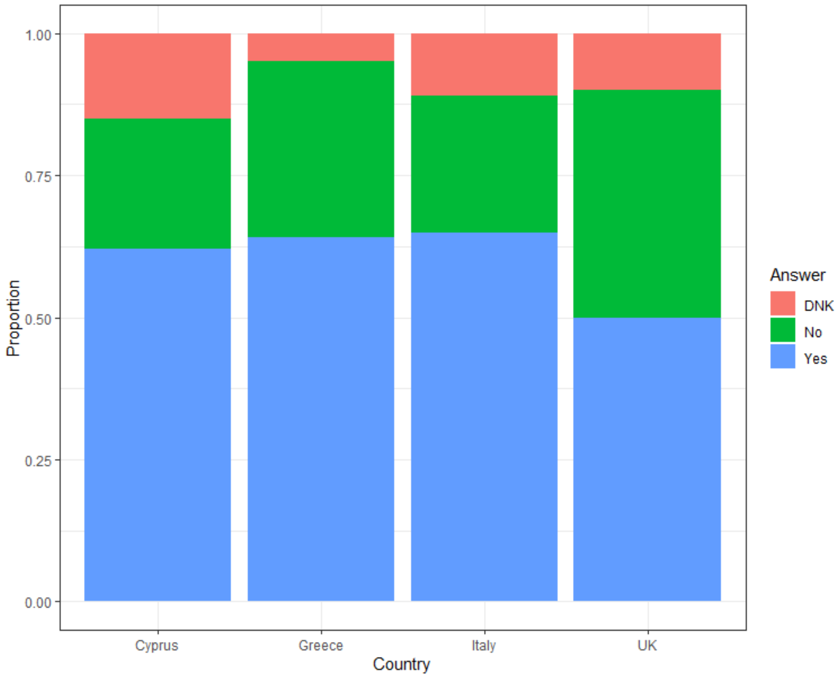

Figure 3. Competition during playing

In figure 4 students are answering a question to select the features they find most appealing in games. As we can see Storyline is the most important feature, followed by challenges and graphics. It is really important to add a good story in a game since our minds are hardwired to store information in a storytelling format.

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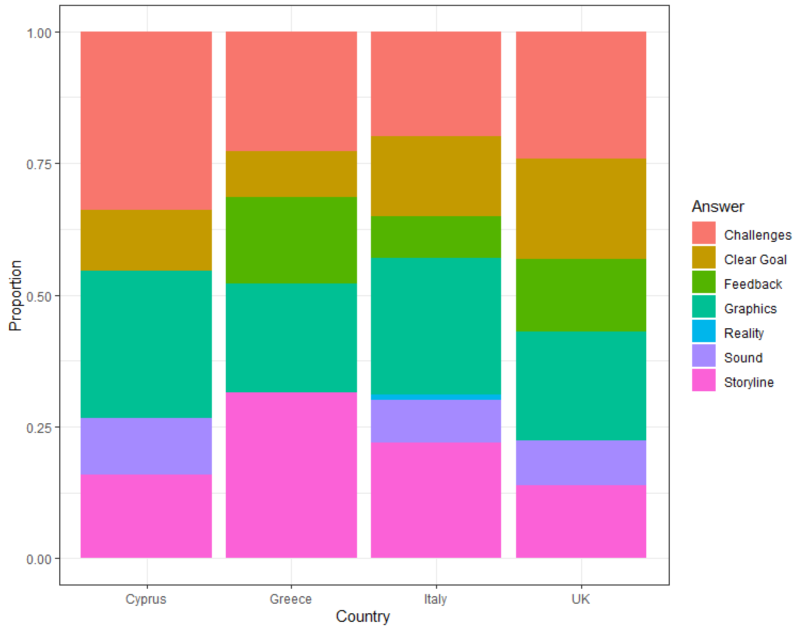

Figure 4. Appealing features in a game according to students

In figure 5 there are answers regarding the question of whether students have played an educational game before. As we can see the majority gives a positive answer. Most children have played educational games, but the real challenge is to create educational games that are really engaging and create flow to children and not just presenting educational information in a media format.

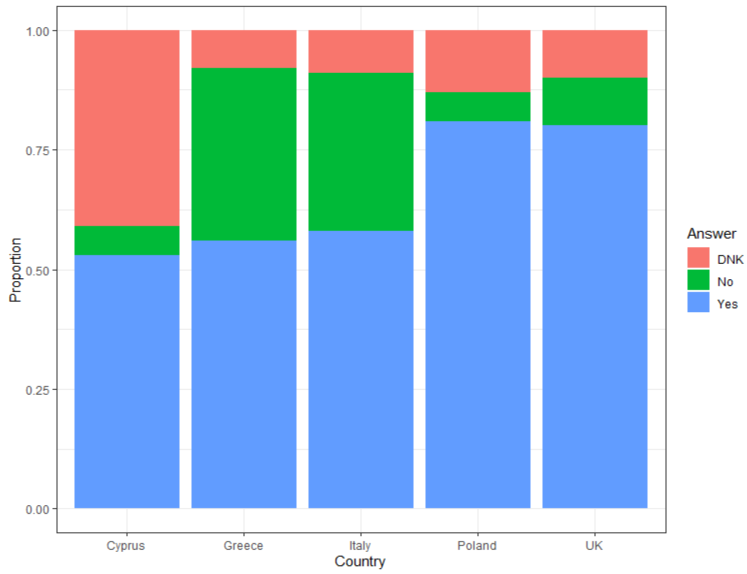

Figure 5. Previous experience with educational games

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In figure 6 students are answering a question related to which device they play the most. As we can see smartphone is the most common answer followed by PC. Thus, creating a mobile game will reach the biggest possible audience.

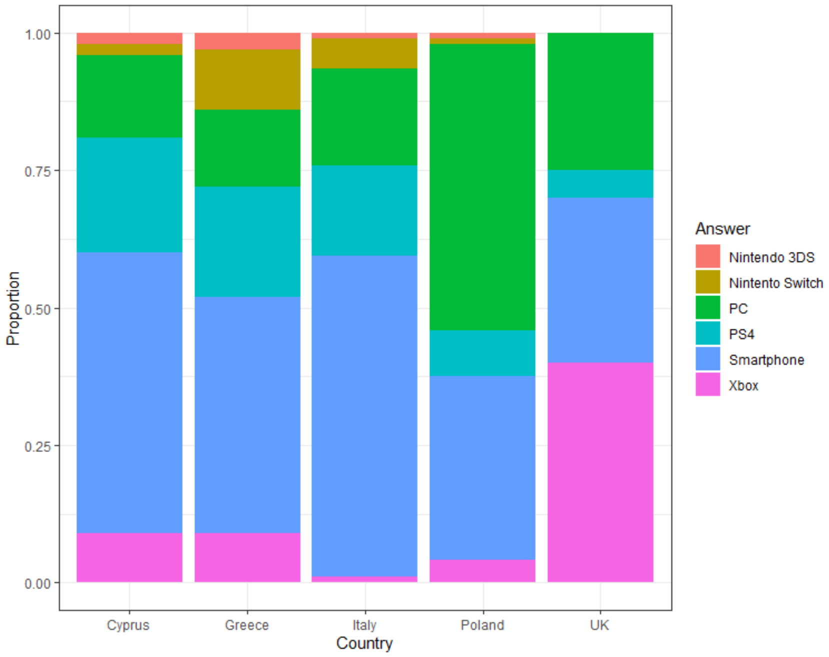

Figure 6. Students preferred device for playing games

In figure 7 children answered a question related to whether they want to create their own character. It is profound that almost all want to have that option. It is certainly a feature that should be added in every online game since personalization of the game is enhanced in that way.

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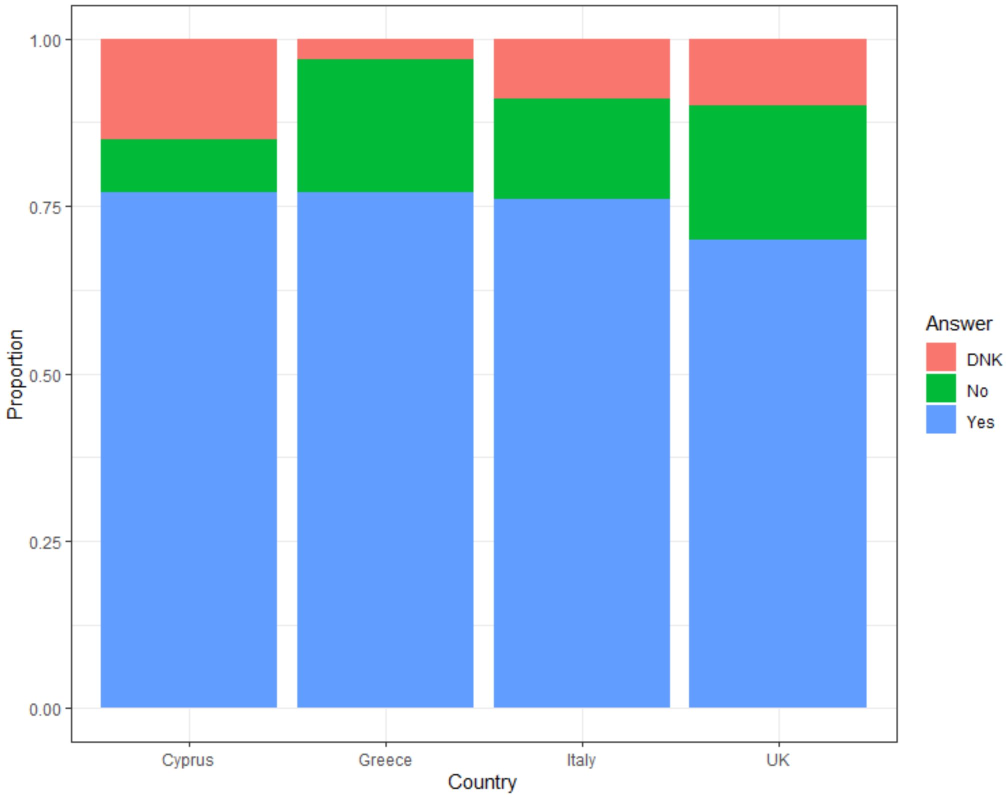

Figure 7. Would you like to create your own character?

In figure 8 children answer a question related to whether they prefer a single user or multiplier game. The majority wants 2 or more players but still a lot of students prefer a single user game. 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.

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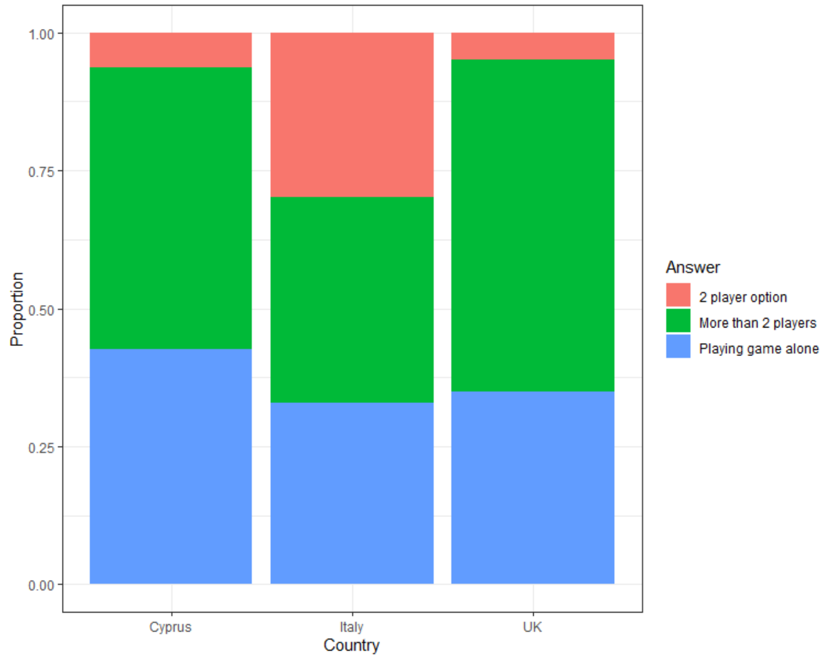

Figure 8. Most preferable interactivity option for students

In figure 9 children answer the question whether they prefer an imagination setting or a Real World. Imagination is the most popular answer (except from Italy). Imagination with some real world elements seems the best option.

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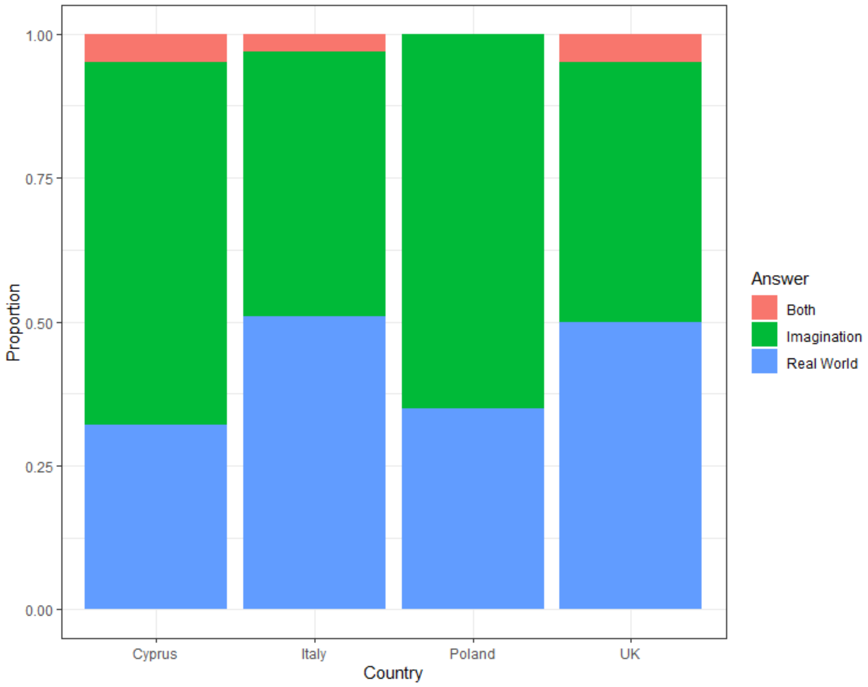

Figure 9. Type of setting in a game

DISCUSSION

CT in education is emerging worldwide. It seems to be a promise for the education of the new generation 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 video game technologies in an educational gaming setting is one technique advocated to help with teaching and learning (also referred to as "serious games"). 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 used serious games have proven good benefits on students as well as learning results (Ater-Kranov et al., 2010; Kazimoglu et al.,2012). 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.

This chapter conducted a literature review on the role of CT, the role of serious games and the relationship between computational thinking and the state-of-the-art of serious games as a didactical approach for students to learn computational thinking ways and principles. Also, this chapter conducted a field research on students' game interests. Specifically, based on students’ responses, the specific features and characteristics of a game that 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.

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Taking all into a consideration, it is evident that most of the students have played an 'educational game' before. The majority of students spend playing games on average 0-2 hours per week but there is a significant percentage of students that play more than 8 hours. The majority of the students used a smartphone to play a game and they prefer to play action, strategy games, sports games, and FSP games in a real-world setting. In terms of interaction, they prefer to play a game with 2 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 helps them to progress. They prefer playing games which 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 mostly 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. Obtaining this information, on the other hand, is vital and will be a next step for us in order 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 intention in the future is to involve also 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.

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- *Storyline*. According to students, it is one attractive game feature. Narrative and storytelling attract students' attention and curiosity. An interesting storytelling also motivates students to continue and complete the game in order to investigate what it is happen and why.

- *Challenge-based approach*. A game should have some real-world challenges. During the game students must be faced with a real problem which needs to be solved. This would allow students to critically think, to identify the possible alternatives, to investigate, and finally to propose solutions. The challenges will enable students to gain deep knowledge and develop their skills.

- *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.

- *Competition*. Students claimed that it is interesting for them to compete with other players during the game. When a competition environment is created in a serious game, motivation and academic performance of students improve significantly (Cagiltay, Ozcelik, & Ozcelik, 2015).

- *Educational robotics*. There are numerous games and applications that engage students in robotics teaching them how to code with robotics. Students through the use of robots involve in problem-solving situations and systems thinking. It is now time to think 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.

Finally, in order to give a systematic and structured evaluation of the game concept, a set of rigorous experiments need to be constructed. These will give 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. The game concept that will be created, will be available to the community.

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 desk 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, centred on CT in education are emerging worldwide. Serious games seem to contribute effectively to this experience, however more

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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 research aims to offer a clearer understanding of CT in education and to provide 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

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

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

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