EAI Endorsed Transactions
on Creative Technologies
Research Article EAI.EU

Educational Game Design for Girls and Boys – Towards an Inclusive Conceptual Model for Learning Programming

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Abstract

INTRODUCTION: Programming is an important skill in the 21st century and it is important to reach and motivate the younger audience. Educational games have proved to motivate students, but research reports about girls not feeling welcome in game environments.

OBJECTIVE: The overall objective of this study is to gather information for the development of a preliminary conceptual model for girl inclusive educational game design.

METHODS: This study was conducted as a requirement-focused Design science study. The focus was set on gathering requirements for a future design and development of educational games on fundamental programming.

RESULTS: A thematic analysis resulted in the main themes of Exploration Without Violence, Collaborative Interaction, Character Diversity, Customisation, Graphics, Game Mechanics, Game Content, and Learning and Motivation

CONCLUSION: The accumulation of results from the literature study and the survey have been merged into a preliminary conceptual model. The conclusion is that a thoughtful consideration of the found factors can support the idea of a Girl Inclusive Educational Game Design.

Keywords: Game design, Girls and gaming, Gender inclusion, Inclusive design, Educational games, Serious games, Game-based learning, Programming education.

Received on 02 October 2023, accepted on 01 November 2023, published on 14 November 2023

doi: 10.4108/eetct.4043

1. Introduction

During the last decade the labour market has showed an increased need for professionals with knowledge and skills in programming [1-2]. Computer science and programming courses are an important, as well as challenging part of education process to meet this need [3]. A contemporary global trend is to integrate programming in various ways in K-12 education [2, 4]. Considering this new and younger learner group there is, at the same time, a need for curriculum development and more joyful learning activities. An old and well-known concept for learner motivation that got its digital renaissance, is the one of game-based learning (GBL) [5]. GBL has been used frequently used in a wide variety of subjects such as science, technology, engineering and mathematics (STEM). There are also research studies reporting on

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promising results for GBL used in programming education [6-7].

To use games in educational contexts has been around for several thousands of years, and long before the appearance of computers and video games in the previous century [8]. In the 21st century the identified 'casual revolution' [9], playing games has become a ubiquitous activity, reaching a larger percentage of the population than ever before. Children and adults often spend considerable amounts of time, playing different types of analogue, digital and so called 'hybrid games'. At the same time, the use of games in educational contexts is today established as a mainstream didactic activity [10]. Moreover, game-based learning has become a support tool for students with different kinds of special needs [11].

Despite many research studies on gender aspects of game design, girls and women do not play videogames to the same extent as boys and men [12-13]. Moreover, researchers have reported that certain game genres seem to be more appealing to girls than to boys, with identified game concepts that many females find repelling [14-15]. Certain types of gameplay have been found to engage boys to a higher degree than what is the case for girls [14, 16]. The use of educational games to learn programming techniques has showed a potential to bring in motivation and active learning into the classroom [17]. However, there are several gender issues to consider in game-based programming education as well [18-19].

The research gap addressed in this study is two-folded. Firstly, to try to identify the specific game design details that make girls feel welcome to a game. This should also involve the identification of design details that have the opposite effect. Secondly, it is essential for game design to investigate the specific design factors for an educational game on learning to program. For a merge of these two aspects authors have combined the data sets from two earlier studies [20-21]. Carried out with a Design science approach, the aim of this study is to collect requirements for the development of a conceptual model. A model for design of educational games on programming where girls and boys find it joyful to play together. The two research questions that guided this study were: RQ1: "Which specific design factors are important for a girl inclusive game design?", and RQ2: "What are elementary school students' perceptions of important design factors for an educational game on computer programming?"

2. Extended background

This laying games in different types on education has a long history, with the use of board games such as Kalaha and Chess to train logic, combinatorics and strategic thinking [8, 22]. To use and build games to make children learn computational thinking and programming is a younger discipline started in the early 1970s with Seymour Papert, LOGO and Turtle Graphics [23, 24].

2.1. Game-based learning

In ancient Greece, the use of games in educational contexts was an applied and discussed idea by philosophers such as Aristotle and Plato. Aristotle presented in his Politics, the ide play (paidiá) as an activity for relaxation and rest from the more serious studies [8]. An idea resembling the one presented in 1977, about playing games to relieve anxiety in programming education [25]. To be compared with Plato that proposed a more integrated role for games and playing in education. He pointed out the more linguistically related concepts of paidiá and paideía (Education and Bildung) as essential. Plato's view is partly like Aristotle's, but with the difference that he saw play as being necessary for education, and as a first important step on the ladder towards true knowledge [8].

The embryo to modern view of GBL that we have today, was formulated in the 17th century when John Amos Comenius presented his systematic theory of education, where playing games (ludus) is the ideal form of learning activities. Comenius' theory of ludus was described in his Schola Ludus [26]. What was new and revolutionary idea in the 17th century was how games and play was presented to be fully integrated in the overall learning process. That "the fun and the serious", like in today's serious games, should be combined. Comenius's 17th century ideas are full of creativity and optimism foreshadowing many modern variations of GBL and active learning [27].

Some hundred years later in the 20th century, several GBL concepts reached the university level in the 1970s introduced by the famous pedagogues Piaget [28] and Vygotsky [29]. Piaget was the pedagogue that presented Comenius GBL concepts for a new target group of pedagogues and academics [30]. With the introduction of computers in educational contexts, the idea of using games to stimulate motivation got a renaissance. Mark Lepper [31] and Thomas Malone [32] firstly presented their separate analyses of how computer games could stimulate intrinsic motivation. Later, their findings on digital games and intrinsic motivation were merged to a foundation for the taxonomy of intrinsic motivation [33]. One of many alignments between Comenius's 17th century ideas and the taxonomy of intrinsic motivation is the American pedagogue and philosopher John Dewey. Comenius and Dewey both criticised the frequent use of root learning in education, and instead promoted learning by activities outside the traditional classroom [34]. Playing games is today involving a higher percentage of the population than ever before [35], and with educational games established as a mainstream learning tool [36].

2.2. Educational games in programming education

Several research studies have found educational games to be good supporting tools for increased motivation in programming education [36, 37]. A wide variety of game solutions have been presented in the field of learning

computer programming. Many of these games were used in research contexts, and only a few games have been published and made publicly available [38]. However, the number of commercial games for learning have increased and are available at stores such as Steam, Ubisoft and Google Play [36]. Two examples of games that teach basic programming concepts are BlocklyGames and Rabbids Coding. Other game developers have chosen to create tailored platforms that work as a service for programming education. Two of the most well-known platforms are CodeCombat and Programming Hero.

At the same time, there are researchers studying game mechanics and suitable gameplay for educational games that could teach programming more effectively compared to the more traditional approaches [38]. Moreover, they explore how players learn, the differences between novice and experienced programmers, and what players find difficult in their game-based learning [39]. The educational games could be classified into those that are free like ToolboX academy, and those that require some kind of payment or subscription such as CodeSpark. Another division is between educational games that focus on text-based programming, and others that are built arond visual programming (Light Bot). Not all the educational games that have been created during the last years are still available, and many stop receiving maintenance, and disappear from the different download sites. There are also games that mainly have been developed for research purposes, and never published publicly [40].

3. Method

This study has been inspired by the idea of Design science as a problem-solving paradigm that seeks to design and develop artefacts and practices [41]. The overall purpose of Design science is to create knowledge in the field of design, and knowledge that can support problem-solving in the design of artefacts and concepts [42]. The choice for this study was the Design science approach outlined by Johannesson and Perjons [43]. A process structure with five discrete but interrelated steps that all could be iterated: 1) Explicate the problem, 2) Defining the requirements, 3) Design and development of an artefact, 4) Demonstration of the artefact, and 5) To evaluate the artefact. Further, this study focuses on the first parts of the Design science process, 1) Explicate the problem and 2) Defining the requirements, which could be labelled a problem and requirements-focused Design science [43, 44].

The main idea of this approach is to identify the requirements for an ongoing design and development of a game artefact (further described in 3.1 Prototype development) and generate more general and useful knowledge on the design and implementation of games in educational settings.

3.1. Prototype development

Design and development of the game prototype was conducted in the game development tool RPG Playground (RPGPlayground.com). This tool enabled the design of a web-based and role-playing inspired game, which could be distributed for testing via a link. The web-based format further enabled testing on multiple devices (such as computers, Chromebooks, and mobile devices), which can be important since many elementary schools use different types of digital devices in the classroom. Inspired by previous research, that has shown promising results on using challenging problem solving in escape rooms for computer science [45, 46], this game was created as a digital escape room that should motivate students and inspire for further learning. The working title of the game is ‘Escape with Python’ (Fig. 1), and the focus is on the basics of programming with the programming language Python, combined with fundamental ideas from Computational Thinking (CT), such as CT concepts, practices, and perspectives [47].

Figure 1. Opening scene of ‘Escape with Python’ (Graphics by Niklas Humble in RPG Playground)

The syllabus framework, created and distributed by the Swedish national Agency for Education, for elementary school teachers’ professional development in programming was used as a guideline for constructing the content of the game (or the challenges in each escape room) [48]. The concepts that constitute the challenges of the game, and were chosen from the syllabus framework, are variables, sequences, conditions, iterations, and functions. The design of the game is that each of the concepts are addressed in two escape rooms, making it a total of 10 rooms to escape. First, the player is guided through the solution with metaphors inspired from Computational thinking and everyday life. Second, the player must solve a problem with increased complexity and with less guidance.

3.2. Data collection

Data were gathered in a combination of a scoping literature review, and through a questionnaire that was answered by elementary school students and teachers that had tested the Escape with Python game.

3.2.1. A scoping review

This part of the data collection was conducted as a scoping review to provide an overview of a specific topic of interest [49]. The scoping review approach has been recommended to use when the selected topic is complex or heterogeneous, and when a study has the purpose of identifying knowledge gaps and to clarify concepts [49,50]. Furthermore, a scoping review is a method to identify the main sources and to find key concepts in a specific research field [49]. This scoping review strived to synthesise research results to gather requirements for a specific target group, as a foundation for future research. Considering the type of literature review and the aim of the study, the research question was formulated concrete to support the chosen research design.

The main search engine to identify research papers of interest was Google scholar. Search strings were combined with the use of Boolean operators OR and AND, based on the main keywords Games, Inclusive, Design, Girls, and Women. Moreover, backward and forward searches were used to identify seminal research publications that have a potential to contribute to answer the research question. After a critical rereading of the result set, 24 research publications published between 1994 and 2022, were selected for a further thematic analysis.

3.2.2. Game demonstration and questionnaire

The game protype for Escape with Python was demonstrated and evaluated by 32 elementary school students during the autumn semester of 2021 and the spring semester of 2022. Data were collected by a questionnaire containing a combination of closed-ended, and open-ended questions. This study has only used the answers to the open-ended questions with feedback on the perception of playing the game, and suggestions on how to improve the game design. Game testers were recruited by an open invitation announced in the virtual learning environment for a professional development course on programming for primary and secondary school teachers. Four teachers responded to the invitation and wanted to test the game together with their students. The questionnaire was sent to these teachers together with a form for informed consent to be distributed among the testers.

Only two teachers were able to carry out the complete testing, and to return the questionnaire answers. One of the teachers used the game as part of a structured introduction to programming, while the other teacher played the game together with students that had showed a general interest for computer programming. From a total of 32 students, 28 where from grade 9, 2 students from grade 8, 1 student from grade 7, and one student that did not specify. Regarding the gender distribution, there were 18 boys, 11 girls and 3 students that did not specify gender. The game was tested in the subjects of technology (23), mathematics (4), and programming (3).

3.3. Data analysis

Both data sources were thematically analysed guided by the six-phase process out-lined by Braun and Clarke [51]. The first phase in this process had a focus on getting familiar with the collected data. This was carried out by reading and rereading the submitted essays and simultaneously taking notes to support memory, and to sketch ideas for the further coding and analysis. Phase two was about starting out the more systematic analysis, and to conduct the actual coding. Braun and Clarke [52, p. 5] have depicted a thematic analysis as "a brick-built house with a tile roof, your themes are the walls and the roof, where your codes are the individual bricks and tiles ". In the next third phase, the code bricks were aggregated into wall elements, with the idea that these elements should capture “something important about the data in relation to the research question, and represents' some level of patterned response or meaning within the data set " [51, p. 82].

The next fourth phase were spent on quality checking. Here the found codes and elements were checked by their consistency and by their relevance to answer the research question. For the fourth phase Braun and Clarke [52] recommended five control questions to facilitate the process:

1. Is this an element, a category, or just a code?
2. If it is an element or a category, what is the quality of this element or category?
3. What are the boundaries of the element or category?
4. Are there enough meaningful data to support this element or category?
5. Is the element or category coherent?

When all elements and categories/themes were checked, the fifth phase consisted of handling the definition and final naming of the themes. The sixth phase finally was to write up the presentation of the found themes and to discuss them.

4. Results and discussions

The results from the two different data sources are first presented separately under 4.1 for the literature review, and then the game demonstration and student survey under 4.2, and finally compared and merged under section 4.3.

4.1. The literature study

Five main themes emerged from the literature search analysis. The first four themes highlight crucial design concepts for an inclusive game design that includes girls. However, the last theme suggests possible issues with an overemphasis of female-oriented features, potentially excluding boys. The themes are presented and examined in separate subheadings below.

4.1.1. Creativity and Customisation

One prominent theme that emerged was that girls exhibit a greater inclination towards video games that inspire creativity. They also appreciate games that allow them to modify various game elements, including characters. Furthermore, girls value the opportunity to create artwork that can be utilised within or outside of the game [53]. Additionally, Spieler and Slany [54] note that in games played by both sexes, girls tend to spend significantly more time engaged in creating artwork than earning game points. This suggests a preference for creative expression and non-violent gameplay, as opposed to the violent feedback found in combat games preferred by boys [56,57]. As recommended in Fullerton et al.'s study [58], there is a need for the possibility to alter the gaming world and the arguably more challenging task of having games and players exert a positive influence on society.

In Sharma et al.'s study [59], it was noted that numerous girls value functionality in games that allows them to personalise in-game components. This could be interpreted as a means for girls to express themselves and showcase their tastes [60]. The customization and creativity aspect of games make them an engaging activity for girls [61]. For instance, the Sims game series [58] prioritizes these elements over gameplay mechanics. Most of the games belonging to the Sims series lack clear goals, which are a defining characteristic of games and are classified as digital dollhouses. In the Sims games, virtual characters may experience negative emotional states such as sadness, moodiness, and depression if they become too isolated from other Sims.

4.1.2. Exploration without violence

It has been identified that there is a difference in the gaming preferences of boys and girls. Boys tend to be more attracted to games that involve combat and violence, whereas girls prefer non-violent competition [62,63]. This difference has also been reported in studies on game creation- Spieler and Slany's study [54] found that boys built more shooter games, while girls preferred to build role-playing games. Furthermore, research has highlighted that girls exhibit a stronger inclination towards designing games with male and female characters and providing more choices for selecting game avatars [55]. These game development studies have also investigated differences in feedback design. It has been suggested that girls typically create games with minimal violence and punitive feedback, whereas boys tend to incorporate game features with violent feedback [55,56, 64]. A study by Dilmaghani [16] recently presented that the attitude of female elite chess players towards competitive chess is influenced by the belief that they must prove themselves to male players. This study highlights the impact of gender bias on the psychology of female chess players.

A statement that origins from the Woman Grandmaster (WGM) Jennifer Shahade [65], and her observations of female chess players elite tournaments. However, it could be argued that the rather low percentage of females in the chess elite, consists of the girls that are more competitive than average. Chess has a clearly higher per-centage of male players in all age groups. Girls seem to prefer exploring and collaborating over violence in games, while also desiring challenging gameplay set in realistic environments with sophisticated graphics and sound design [64, 66]. Additionally, research has indicated that girls require gameplay with diverse activities, rich narrative, and characters, combined with social interaction [67,68]. Although some of these studies in this field were conducted over two decades ago, the presence of violence in digital games persists. Not that surprising, but the balance seems better in the domain of educational or serious games.

4.1.3. Collaborative interaction

The studies on children creating games also points out that boys to a higher degree liked to build competition and combat games, while girls were more interested to build games with social interaction. In the early landmark study on the gender differences in game design by Kafai [46], it was found that girls created games with a higher degree of social interaction, whereas boys chose to create games with combat interaction. Miller et al. [66] also reported from their focus group discussions that girls preferred games with collaboration, instead of combat games. Several other studies have pointed out that girls in general want to play games with social interaction related to a rich narrative with sophisticated game characters [67,68]. As concluded by Dickey [64, p. 78]: "There are many commonalities between most of the studies concerning female-oriented design, but the most notable is the importance placed on collaboration and community".

One of several ways of sorting games into genres is to group them as competition games, combat games or collaboration games. Findings from several studies indicate that boys fancy combat games [54,55], whereas girls prefer a game design that involves collaboration [64, 68]. Competition games fall somewhere in the middle, and Taylor [70] notes that girls are more likely to enjoy competition games when they involve collaboration. This could be compared to how Comenius, in the 17th century, described how he wanted to combine peaceful and serious gaming with collaboration and competition to stimulate the learning process [71].

4.1.4. Character diversity

As highlighted in the seminal studies by Kafai [55, 68], girls prefer games with both male and female characters, which also is reflected in games design where girls more often creates both male and female game characters. Girls

also seem to like non-gender-specific characters in realistic settings [64, 70], if compared to boys. In a recent study by Leonhardt and Overå [72, p. 7] it was pointed out that "Both boys and girls were critical of gender representation in video games", and around 25 years after Kafai's studies the unbalanced gender representation seems to remain. Or as formulated by a 9th grade girl in the same study: "The characters in video games are mostly guys. There are lots of war games. I don't play any video games where the main character is a man". This girl described herself as having gaming as a passion, but at the same time being reluctant to many digital games since they lack "good female characters". Another girl, in the same study, mentioned the passive and help-less princess character in the Super Mario games to be an example of an uninspiring female character [72, p. 7].

Spangenberger et al. [73] have highlighted the importance of inspiring female role models for girls. They found that games featuring female protagonists increased girls' interest in technical subjects. A study on educational games designed for learning computer programming revealed two intentionally distinct games; the first was genuinely gender-neutral, whereas the second had a design specifically geared towards girls. The study's conclusion was that both games were equally effective at achieving learning objectives. However, participants with a preference for girl-oriented games were more motivated to learn computer programming when playing the girl-oriented game. This finding contradicts Kafai's study [69], which stated that girls prefer non-gender-specific game characters. An interesting contradiction that bridges over to the next the theme 'Gender specific game design', and at the same time relates to the first theme, 'Creativity and customisation'. Sharma et al. [74] highlighted in their study on serious game design for girls learning computer science that personalisation ranked among the most desired design factors. Additionally, personalisation was found to inspire girls to view themselves as role models [74,75]. Maybe that customisation and personalisation are key concepts for inclusive design, and in more aspects than the one of gender?

4.1.5. Girl specific game design

Another approach to address the challenge with getting more girls and women into games and game design is through gender specific design, and to create a so called "virtuous cycle" [58]. Girls and women may be more engaged in playing and creating games if there were more games that appealed to them, leading to more games being created by females and an iterative increase of appealing games [58]. However, games that only target women and girls may not lead to an increase in female game designers, and it could exclude men and boys. For instance, a game with a feminine theme centered on designing dresses may appeal to many women and girls, yet it will probably not inspire them to pursue an engineering career [64, 76]. It is recommended to provide boys and girls with equal chances to explore fields that might not typically attract them. It is also possible that girls may enjoy active gameplay, while boys may appreciate a more creative experience [77].

In the choice between a gender specific design, and an inclusive design, the choice must be an inclusive design. A metaphor for this could be the wide walls concept in the Scratch programming language, the walls should be wide enough to engage people with many different preferences, and different learning styles in the same learning environment [78]. Finally, as brought up by Dondlinger [79], the presumption that girls and women differ from boys and men in gaming habits, such as it is not done with the same intensity and duration, has little empirical support.

4.2. Game demonstration and student survey

The answers to the open-ended questions contained several interesting perceptions about the game, and also some constructive suggestions for improvements. Results from the thematic analysis are presented in the following sub-sections.

4.2.1. Game Graphics and Customisation

Student feedback suggests that the game's retro-feel was popular, as it reminded them of similar games they had played in the past. However, there were also some critical comments, with students requesting improvements to the overall design. Specifically, they suggested adding more details to the rooms, enhancing the graphics' general quality, and including background music. As previously discussed in literature regarding educational games, academic projects may struggle to match the graphical quality of commercial AAA games [80]. Nevertheless, certain students expressed a fondness for the game's minimalistic design, citing that it allowed them to easily maintain an overview of their progress. Finally, the students proposed that each player should have the ability to personalise their game characters and have full control over how they were visually represented in the game: "Good, the design was simple, and you did not get overwhelmed. But you should be able to do customisation on the character that you play and design its' look." (Quote 1. Student about graphical design and customisation of the game)

4.2.2. Game mechanics and customisation

The results from the analysis also show that many students perceived the gameplay as unclear, and that the gameplay lacked consistency. An example is that the problem-solving approach in one room did not reoccur in the next (Quote 2). This raises the question if it would be good didactics to always solve problems in the same way, which would be a repeating routine in this type of game. It can also be argued that problem-solving in programming is versatile, and that a skilled programmer needs a toolbox rather than a tool. On the other hand, some students wrote that the game was easy to play and understand. These

variations could probably be explained by the students previous gaming habits, and to which extent they have played different types of games Similar to the opinions expressed about customisation in the previous section, some students recommended that the gameplay should offer greater autonomy and alternatives. For instance, gamers ought to have the ability to explore the game world more freely, as well as access facilities for writing code in the game, rather than just choosing from pre-made code. This would necessitate a more intricate game implementation but would result in more robust learning outcomes. In some rooms you used those glowing things to do stuff but in other rooms you walked up to some character to do stuff. It feels a bit inconsistent." (Quote 2. Student about gameplay and game mechanics)

4.2.3. Game content

As for many other game analyses, results show that players have strong variations in their perceptions of the level of difficulty. The most probable explanation to this, is the player's prior experience of programming, which have variations in the testing group. Furthermore, there are suggestions regarding the improvement of the presentation of code and instructions in the escape room dialogues. Students have highlighted that there are too many dialogues to read and that the codes were hard to comprehend when presented in a game dialogue. Additionally, students indicated that it was challenging to remember all the necessary details to solve the issues in the escape rooms. Additionally, several students proposed enhancing the game's excitement by including a 'life-system' to indicate the number of attempts available to the players for addressing a challenge (Quote 3). This would be an improvement that addresses the issue highlighted by some students: It is possible to cheat or guess your way through the game, since there are no penalties for wrong answers or wrong choices. “I think that the game should have some sort of life-system. Because you can test all the answers without consequences. You don’t really have to think to finish the game.” (Quote 3. Student about the content and the challenge of the game)

4.2.4. Learning and motivation

Last but not least, learning and motivation, where an educational game without learning hardly could be called an educational game. In addition, an educational game that do not create motivation would never be a decent alternative to traditional teaching and learning. A positive finding was that students deemed the game engaging and indicated that they learned from it. Other positive remarks were made about the game's relevance to school content and utility. In addition, students reported learning about loops, iterative thinking, precision, and accuracy. In terms of motivation, the participant expressed a desire to expand their programming knowledge and create their own games. This aligns with another aspect of game-based learning for programming education, which involves learning to program through game development as a complement to learning through gameplay. To get everyone aboard in an average primary school class, the approach must involve initial scaffolding to lower the entry level. The findings highlight a compelling comparison between educational games and leisure games. A few students expressed disinterest in programming or programming-related games. They found it tedious and suggested a diversion from the programming context to make it enjoyable (Quote 4). Other students reported enjoying the game and finding it enjoyable as an educational tool. However, they also indicated a lack of interest in playing the game outside of the school setting. "To some degree the game was fun. But I think it was very much the same over and over again. Maybe it should be about something else than programming. For example, about going on an adventure." (Quote 4. Student about motivation and enjoyment)

4.3. Comparing and merging the results

Both 4.1 and 4.2 here above show results that can answer the research questions. In Figure 2, the themes found in the literature study can be found in the upper part of the left circle, and the themes found in the game evaluation questionnaire have been placed in the upper part of the right circle. The intersection of the two circles shows the themes that occurred in both the studies. All together, these themes create a conceptual model for Girl Inclusive Educational Game Design, involving the idea of designing educational games with Wide Walls, a High Ceiling and a Low Threshold.

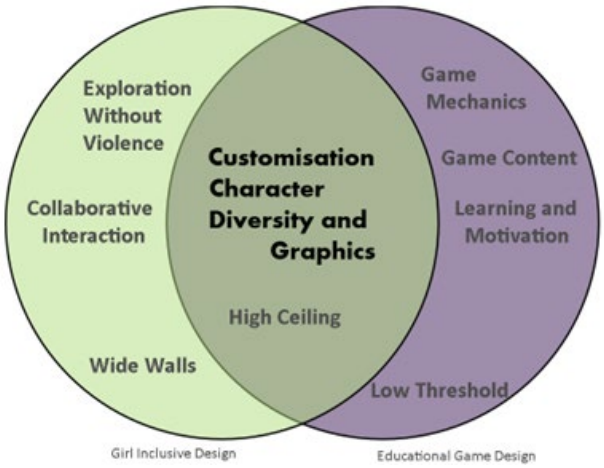

Figure 2. Girl Inclusive Educational Game Design
(Graphics by Peter Mozelius)

Looking at the themes in the intersection set, it would also be a challenging game construction to implement freedom for players to configure the game world exploration, with individual gaming paths. Definitely less complex, and maybe more important to implement, are

configuration features for the game characters. As highlighted by Leonhardt and Overå [72], games without inspiring female characters will put girls off. Additionally, female protagonists in games have valid reasons for inclusion, as suggested by Spangenberger et al. [73]. From a boy or male perspective, it can be motivating to configure protagonists, antagonists and heroes for several reasons. With regards to Graphics, developers of educational games find it challenging to compete with the high-end graphics of commercial-off-the-shelf (COTS) games. For inclusive design aimed at girls, it is recommended, as in Osunde et al. [81], to use cartoon graphics and avoid dark colour schemes.

If desired learning outcomes are to be achieved, all three factors are crucial for themes in the upper section of the right circle in an educational game. If game mechanics are inadequate, learners may not enjoy playing, resulting in a product that resembles an e-book rather than a game. Insufficient game content may render it entertaining, but not a valuable educational game in which players acquire knowledge. An essential aspect of numerous games is the increasing level of difficulty to maintain players within the flow channel. The concept of the 'flow channel' was defined by Csikszentmihalyi [82] as a state of heightened enjoyment and intense focus on a task, falling within the spectrum bounded by boredom and anxiety.

5. Conclusion

The merge of results from the two separate studies with separate research questions resulted in the conceptual model depicted in Figure 2. A thoughtful consideration of the found factors could guide the design of girl inclusive educational games. In the presented conceptual model, all factors are equally weighted, but the factors found in both studies are probably the most neglected ones. To implement all aspects of customisation in all types of games would be rather complex and time consuming. On the other hand, the identified need for character diversity and creative features for character customisation would be relatively easy to implement. A design that adds features for customisation can certainly support the idea of games with wide walls and a high ceiling. Finally, the presented model must be further tested in future research on inclusive game design.

Acknowledgements

This study was supported by funding from the Gaming4Coding project Gaming4Coding. This is a two-year Erasmus+ project, with the aim of developing a game where secondary school students should learn text-based programming. Moreover, we would like to thank the DTML research lab at the University of Gävle.

References

[1] Admiraal W, Post L, Guo P, Saab N, Makinen S, Rainio O, Vuori J, Bourgeois J, Kortuem G, Danford G. Students as future workers: Cross-border multidisciplinary learning labs in higher education. International Journal of Technology in Education and Science. 2019 Feb 4;3(2):85-94.

[2] Tikva C, Tambouris E. Mapping computational thinking through programming in K-12 education: A conceptual model based on a systematic literature Review. Computers & Educa-tion. 2021 Mar 1;162:104083. .

[3] Konecki M. Problems in programming education and means of their improvement. DAAAM international scientific book. 2014 Jan 1;2014:459-70.

[4] Szabo C, Sheard J, Luxton-Reilly A, Becker BA, Ott L. Fifteen years of introductory pro-gramming in schools: a global overview of K-12 initiatives. In Proceedings of the 19th Koli Calling International Conference on Computing Education Research 2019 Nov 21 (pp. 1-9).

[5] Partovi T, Razavi MR. The effect of game-based learning on academic achievement moti-vation of elementary school students. Learning and Motivation. 2019 Nov 1;68:101592.

[6] Chen PY, Hwang GJ, Yeh SY, Chen YT, Chen TW, Chien CH. Three decades of game-based learning in science and mathematics education: an integrated bibliometric analysis and systematic review. Journal of Computers in Education. 2021 Oct 31:1-22.

[7] Theodoropoulos A, Lepouras G. Digital game-based learning and computational thinking in P-12 education: a systematic literature review on playing games for learning programming. Handbook of Research on Tools for Teaching Computational Thinking in P-12 Education. 2020:159-83.

[8] Hellerstedt A, Mozelius P. Game-based learning: A long history. In Irish Conference on Game-based Learning 2019, Cork, Ireland, June 26-28, 2019 (Vol. 1).

[9] Juul J. A casual revolution: Reinventing video games and their players. MIT press; 2010.

[10] Moreno-Ger P, Martinez-Ortiz I, Freire M, Manero B, Fernandez-Manjon B. Serious games: A journey from research to application. In2014 IEEE Frontiers in education conference (FIE) proceedings 2014 Oct 22 (pp. 1-4). IEEE.

[11] Hersh M, Leporini B. Serious games, education and inclusion for disabled people editorial. British Journal of Educational Technology. 2018;49(4):587-95.

[12] Carr D. Contexts, pleasures, and preferences: Girls playing computer games. In Growing Up Online 2007 (pp. 151-160). Palgrave Macmillan, New York.

[13] Lima L, Gouveia P. Gender Asymmetries in the Digital Games Sector in Portugal. In-DiGRA'20-Proceedings of the 2020 DiGRA International Conference: Play Everywhere, Tampere 2020.

[14] Subrahmanyam K, Greenfield PM. Computer games for girls: What makes them play. From Barbie to Mortal Kombat: gender and computer games. 1998 Dec 1:46-71.

[15] Cunningham CM. Games girls play: Contexts of girls and video games. Lexington Books; 2018 Apr 20.

[16] Dilmaghani M. Chess girls don't cry: Gender composition of games and effort in competi-tions among the super-elite. Journal of Economic Psychology. 2022 Mar 1;89:102482.

[17] Mathrani A, Christian S, Ponder-Sutton A. PlayIT: Game based learning approach for teaching programming

concepts. Journal of Educational Technology & Society. 2016 Apr 1;19(2):5-17.
[18] Buffum PS, Frankosky M, Boyer KE, Wiebe EN, Mott BW, Lester JC. Collaboration and gender equity in game-based learning for middle school computer science. Computing in Science & Engineering. 2016 Mar 4;18(2):18-28.
[19] Malik S, Al-Emran M, Mathew R, Tawafak R, AlFarsi G. Comparison of E-learning, M-learning and game-based learning in programming education–a gendered analysis. International Journal of Emerging Technologies in Learning (iJET). 2020 Aug 14;15(15):133-46.
[20] Mozelius P, Humble N, Sällvin L, Öberg L-M, Pechuel R, Fernández-Manjón B. How to get the girls gaming – a literature study on inclusive design. In 16th European Conference on Game Based Learning (ECGBL 2022), 2022. Academic Conferences International Limited.
[21] Humble N, Mozelius P. Refurbishing the Educational Escape Room for Programming – Lowering the Threshold and Raising the Ceiling. In 16th European Conference on Game Based Learning (ECGBL 2022), 2022. Academic Conferences International Limited.
[22] Moore G. The Mysterious Origin And Strange Descent of Chess: The Path of Evolutionary Inventive Drift Gilbert Moore. 2015
[23] Papert SA, Solomon C. NIM: a game-playing program. 1970
[24] Abelson H, Bamberger J, Goldstein I, Papert SA. Logo progress report 1973-1975.
[25] Shneiderman B. Teaching programming: A spiral approach to syntax and semantics. Computers & Education. 1977 Jan 1;1(4):193-7.
[26] Comenius JA. Schola ludus seu Encyclopaedea Viva. Januae Linguarum praxis Comica.
[27] Hellerstedt A, Mozelius P. From Comenius to Counter-Strike, 400 years of game-based learning as a didactic foundation. 12th Proceedings of ECGBL. 2018. 1:232-9.
[28] Piaget J. Play, dreams and imitation in childhood. Routledge; 2013 Jul 4.
[29] Vygotsky LS, Cole M. Mind in society: Development of higher psychological processes. Harvard university press; 1978.
[30] Piaget J. The significance of John Amos Comenius at the present time. John Amos Comenius on Education. 1967:1-31.
[31] Lepper MR, Greene D. Turning play into work: Effects of adult surveillance and extrinsic rewards on children's intrinsic motivation. Journal of personality and social psychology. 1975 Mar;31(3):479.
[32] Malone TW. Toward a theory of intrinsically motivating instruction. Cognitive science. 1981 Oct 1;5(4):333-69.
[33] Malone TW, Lepper MR. Making learning fun: A taxonomy of intrinsic motivations for learning. InAptitude, learning, and instruction 2021 May 30 (pp. 223-254). Routledge.
[34] Snelgrove D. Testing, Experience, and Reason: Perspectives from Comenius and Dewey. Journal of Philosophy & History Education. 2017;67(1):35-52.
[35] Juul J. A casual revolution: Reinventing video games and their players. MIT press; 2010.
[36] Areizaga Blanco A, Engström H. Patterns in mainstream programming games. International Journal of Serious Games. 2020;7(1):97-126.
[37] Lindberg RS, Laine TH. Formative evaluation of an adaptive game for engaging learners of programming concepts in K-12. International Journal of Serious Games. 2018 Jun 18;5(2):3-24.
[38] Miljanovic MA, Bradbury JS. A review of serious games for programming. In Serious Games: 4th Joint International Conference, JCSG 2018, Darmstadt, Germany, November 7-8, 2018, Proceedings 4 2018 (pp. 204-216). Springer International Publishing.
[39] DeLozier C, Shey J. Using Visual Programming Games to Study Novice Programmers. International Journal of Serious Games. 2023 Jun 7;10(2):115-36.
[40] Díaz J, Lopez JA, Sepúlveda S, Villegas GM, Ahumada D, Moreira F. Evaluating aspects of usability in video game-based programming learning platforms. Procedia Computer Science. 2021 Jan 1;181:247-54.
[41] Hevner AR, March ST, Park J, Ram S. Design science in information systems research. MIS quarterly. 2004 Mar 1:75-105.
[42] Engström E, Storey MA, Runeson P, Höst M, Baldassarre MT. How software engineering research aligns with design science: a review. Empirical Software Engineering. 2020 Jul;25(4):2630-60.
[43] Johannesson P, Perjons E. An Introduction to Design Science 2014. Springer, Cham
[44] Humble, N., Mozelius, M. Design science for Small Scale Studies: Recommendations for Undergraduates and Junior Researchers. In: European Conference on Research Methodology for Business and Management Studies (ECRM 2023). 2023 Sep 6: 87-92. ACI Academic Conferences International.
[45] Borrego C, Fernández C, Blanes I, Robles S. Room escape at class: Escape games activities to facilitate the motivation and learning in computer science. JOTSE. 2017;7(2):162-71.
[46] Hacke A. Computer science problem solving in the escape game “Room-X”. In International Conference on Informatics in Schools: Situation, Evolution, and Perspectives 2019 Nov 18 (pp. 281-292). Springer, Cham.
[47] Brennan, K., Resnick, M. New frameworks for studying and assessing the development of computational thinking. In: Proceedings of the 2012 annual meeting of the American educational research association.
[48] Humble N, Mozelius P, Sällvin L. You can't Escape Learning, but Maybe you can get out of the room!: Game-based Learning for Programming Education. In: 15th European Conference on Game Based Learning (ECGBL 2021). 2021 Sep: 359-367.
[49] Munn Z, Peters MD, Stern C, Tufanaru C, McArthur A, Aromataris E. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. BMC medical research methodology. 2018 Dec;18:1-7.
[50] Pham MT, Rajić A, Greig JD, Sargeant JM, Papadopoulos A, McEwen SA. A scoping review of scoping reviews: advancing the approach and enhancing the consistency. Research synthesis methods. 2014 Dec;5(4):371-85.
[51] Braun V, Clarke V. Using thematic analysis in psychology. Qualitative research in psychology. 2006 Jan 1;3(2):77-101
[52] Braun, V. & Clarke, V. Thematic analysis. In H. Cooper, P. M. Camic, D. L. Long, A. T. Panter, D. Rindskopf, & K. J. Sher (Eds.), APA handbook of research methods in psychology, vol. 2: Research designs: Quantitative, qualitative, neuropsychological, and biological (p. 57–71). 2012. American Psychological Association.

[53] Kinzie MB, Joseph DR. Gender differences in game activity preferences of middle school children: implications for educational game design. Educational Technology Research and Development. 2008 Dec;56(5):643-63.
[54] Spieler B, Slany W. Game development-based learning experience: Gender differences in game design. arXiv preprint arXiv:1805.04457. 2018 May 11.
[55] Kafai YB. Gender differences in children's constructions of video games. Interacting with video. 1996;11:39-66.
[56] Kafai YB. Gender differences in children's constructions of video games. Interacting with video. 1996;11:39-66.
[57] Kafai YB, Burke Q. Beyond game design for broadening participation: Building new clubhouses of computing for girls. GenderIT 2014. 2014
[58] Fullerton, T., Fron, J., Pearce, C., & Morie, J. Getting girls into the game: Towards a 'virtuous cycle'. Beyond Barbie and Mortal Kombat: New perspectives on gender and gaming, 2008. 161-176.
[59] Sharma K, Torrado JC, Gómez J, Jaccheri L. Improving girls' perception of computer science as a viable career option through game playing and design: Lessons from a systematic literature review. Entertainment Computing. 2021 Jan 1;36:100387.
[60] Çakır NA, Gass A, Foster A, Lee FJ. Development of a game-design workshop to promote young girls' interest towards computing through identity exploration. Computers & Education. 2017 May 1;108:115-30.
[61] Ioannidou A, Repenning A, Webb DC. AgentCubes: Incremental 3D end-user development. Journal of Visual Languages & Computing. 2009 Aug 1;20(4):236-51
[62] Ray SG. Gender inclusive game design: Expanding the market (Advances in Computer Graphics and Game Development Series). Charles River Media, Inc.; 2003 Sep 1
[63] Vermeulen L, Van Looy J, Courtois C, De Grove F. Girls will be girls: a study into differences in game design preferences across gender and player types. InUnder the mask: perspectives on the gamer conference 2011 2011.
[64] Dickey MD. Girl gamers: The controversy of girl games and the relevance of female-oriented game design for instructional design. British journal of educational technology. 2006 Sep;37(5):785-93.
[65] Shahade J. Play Like a Girl!. Mongoose Press; 2010.
[66] Miller L, Chaika M, Groppe L. Girls' preferences in software design: Insights from a focus group. Interpersonal Computing and Technology. 1996 Apr;4(2):27-36.
[67] De Castell S, Bryson M. Retooling play: Dystopia, dysphoria, and difference. From Barbie to Mortal Kombat: gender and computer games. 1998 Dec 1:232-61.
[68] Rubin A, Murray M, Ashley J. What kind of educational computer games would girls like? Paper presented at the annual meeting of the American Educational Research Association. In Retrieved June 1997.
[69] Kafai, YB. Minds in play: computer game design as a context for children's learning. Hillsdale, N.J.: Lawrence Erlbaum Associates. 1994.
[70] Taylor TL. Multiple pleasures: Women and online gaming. Convergence. 2003 Mar;9(1):21-46.
[71] Hellerstedt A, Mozelius P. From Comenius to Counter-Strike, 400 years of game-based learning as a didactic foundation. 12th Proceedings of ECGBL. 2018 Oct 1:232-9
[72] Leonhardt M, Overå S. Are there differences in video gaming and use of social media among boys and girls? —A mixed methods approach. International Journal of Environmental Research and Public Health. 2021 Jun 4;18(11):6085.
[73] Spangenberger P, Kapp F, Kruse L, Hartmann M, Narciss S. Can a serious game attract girls to technology professions?. International Journal of Gender, Science and Technology. 2018 Jun 26;10(2):253-64.
[74] Sharma K, Torrado JC, Gómez J, Jaccheri L. Improving girls' perception of computer science as a viable career option through game playing and design: Lessons from a systematic literature review. Entertainment Computing. 2021 Jan 1;36:100387.
[75] Alserri SA, Zin NA, Wook TS. Gender-based engagement model for designing serious games. In2017 6th International Conference on Electrical Engineering and Informatics (ICEEI) 2017 Nov 25 (pp. 1-5). IEEE.
[76] Vail K. Girlware: Software companies are targeting girls, but is their marketing on the mark. Electronic School,(June 1997), www. electronic-school. com/0697f1. html (Sited 01-Jan-2005). 1997.
[77] Alserri SA, Zin NA, Wook TS. Gender-based engagement model for designing serious games. In2017 6th International Conference on Electrical Engineering and Informatics (ICEEI) 2017 Nov 25 (pp. 1-5). IEEE.
[78]
[79] Resnick M, Maloney J, Monroy-Hernández A, Rusk N, Eastmond E, Brennan K, Millner A, Rosenbaum E, Silver J, Silverman B, Kafai Y. Scratch: programming for all. Communications of the ACM. 2009 Nov 1;52(11):60-
[80] Dondlinger MJ. Educational video game design: A review of the literature. Journal of applied educational technology. 2007 Jul;4(1):21-31.
[81] Ljungkvist P, Mozelius P. Educational games for self learning in introductory programming courses-a straightforward design approach with progression mechanisms. In Proceedings of The 6th European Conference on Games Based Learning, ECGBL, 2012 (pp. 285-293).
[82] Osunde J, Bacon L, Mackinnon L. Gender differences and digital learning games–one size does not fit all. InInternational conference on gender research 2018 Apr 12 (p. 271).
[83] Csíkszentmihályi M. The Experience of flow in work and play. 1975.