Game Design Based Learning of Programming

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Abstract

We will present game-based learning and the use of game design as a method for teaching programming in primary and secondary schools in the paper. A lot of knowledge about game-based learning in general was collected in the last decade, but very few information and resources can be found on how to use game design as a method for teaching programming. We have made an extensive study of different approaches to game design-based learning with special emphasis on learning programming for novice programmers. The results will be used as a foundation for the development of methodology in the Erasmus+ international project Coding for Girls. This project addresses open and innovative education and training embedded in the digital era by targeting programming skills that are high in demand in a technology driven society. The project also aims at addressing the gap between male and female participation in computer science education by introducing early methodological learning interventions that make computer programming attractive for girls and boys.

1 Introduction

Leading psychologist of the last century emphasized importance of child's play on development of emotional, social, physical and cognitive. Play is one of the most important activities for development of important skills for life, regardless of age or level of development. It can be characterised by quick adoption to new circumstances and by handling change with ease. When child plays, she discovers basic concepts from real world and first fundamental relationships between them are made.

Lev Semjonovic Vygotsky, Russian psychologist, asserted that game contains in a concentrated form all developmental tendencies and that the most significant psychological achivements of the early childhood occur while children engage in play [Vyg67]. Jean Piaget, the author of the most influential theory of children's intellectual development claimed that the primary functions of all organisms is adapting to an environment and play is incorporation of new intellectual material into the already existing cognitive structures, without a corresponding alteration of the structures themselves [Pia62]. He also stated that play is consolidation of newly learned behaviour. Jerome Bruner, American educational and cognitive psychologist, born in 1915, stated that play provides a comfortable and relaxed atmosphere in which children can learn to solve variety of problems, making them able to efficiently cope with complex problems of real world [Bru67].

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Nowadays, games and gaming are only used more frequently at the earliest stages of child development at home and in kindergarten. Learning in school is still too often based on traditional transmission of knowledge within a teacher- centered model with passive students. Instruction is usually abstract and decontextualized, and as such it is not suitable for students. On the other hand, learning theories, developed in the last century, promote new approaches to teaching and learning that are student centered, problem based, directed to higher ordered educational goals on higher taxonomic levels, motivational and often supported by ICT.

2 Games And Learning Theories

A lot of educational computer games were designed according to **behavioristic theory of learning** in the past. They were implemented in the form of programmed instruction. Learners were offered a stimulus in the form of a question or any other type of task or problem to be solved. Learners response immediately by selecting one of the offered answers. If the answer is correct, the game provides some kind of positive response in a form of a positive character reaction or happy tune that stimulates positive emotions. This instance of action-reaction pair enforce connection between a question and the correct answer. In the case of wrong answer, a reaction is provided in a form of negative stimuli and the connection is weakened. Point-and-click games and quizzes have drill and practice concept build in and are typical representatives of games, based on behaviourism. They are suitable to learn basic arithmetic operations or to support memorisation of factographic data, i.e. learning goals on the lowest levels of Bloom39;s taxonomy.

Cognitive learning theory emphasizes learner39;s cognitive activity and formation of appropriate mental models. Learners learn fundamental concepts from her teacher or form learning resources and then use logical deduction to gain new knowledge. Puzzles and strategy games as an environment for decision-making examples of the cognitivist approach. The most advanced forms of cognitive theory based games are based on intelligent tutoring systems, where machine learning algorithms are employed to model student and expert knowledge in order to provide personalized learning material.

Constructivism is an alternative view suggesting that learners construct their own knowledge; a number of individually constructed knowledge representation, all equally valid. Learning is an active process of constructing (rather the acquiring knowledge), built recursively on knowledge that user already has. In a process of construction, sensory data is combined with existing knowledge to create new viable mental models, which are in turn the basis for further construction.

Constructivist learning emphasizes discovery and inquiry learning arguing that students should be placed in an environment (which can be modeled with computer game) where they construct their own knowledge. Three fundamental principles define the constructivist view of learning:

- each person forms her own representation of knowledge,
- learning occurs when the learners‘ exploration uncovers an inconsistency between their current knowledge representation and their experience,
- learning take place within a social context and interaction between learners and their peers is a necessary part of the learning process.

Learning materials provide instruction that consists of supporting knowledge construction rather than declaring the knowledge in behavioristic fashion. Computer game simulations replicate various real-life scenarios in computer game format. They present model of abstracted reality in which learner inhabit a certain role. The task of teacher is to provide guidance and feedback when student is learning, i.e. constructing viable mental models.

Games can lead to changes in attitudes, behavior, and skills of the player. Shute and Ke [Shu12] found out that there is convergence between the core elements of a good game and the characteristics of productive learning. Game design has a lot to teach us about learning, and contemporary learning theory can teach us about designing better games. [Shu12]. Marshall McLuhan, Canadian philosopher of communication theory, who foresaw World Wide Web in the sixties of previous century, when he talked about *global village*, stated: ”Anyone who makes a distinction between games and learning doesn‘t know the first thing about either.

Whitton [Whi12] proposed a framework for good practice in serious games design from an active learning perspective. According to his guidelines, the game environment should support active learning by encouraging exploration, problem-solving and enquiry, engender engagement with explicit and achievable goals, be appropriate for the learning context, support and provide opportunities for reflection, provide equal opportunities for all

students, provide ongoing support with a gradual introduction of increasing complexity, and be supported with some kind help or hints.

3 Games Based Learning

Use of digital games for learning has to be undertaken with a high degree of pragmatism. Serious games, sometimes called also didactic or learning games, have to be designed to facilitate some learning objectives [Zap11], [Zap13]. As game-based learning is more time consuming than traditional ways of learning, use of games can only be justified if learning objectives cannot be efficiently achieved otherwise. In most cases, game is not a stand-alone activity but rather part of learning of activities that can be carried out before gameplay, during gameplay, or after it. Gameplay is a term used to define the way players interact with a certain computer game.

Activities before gameplay usually represent an introduction where teacher can present the rules and the goals of the game, the context of the game, or even learning goals, hidden in the game. These activities can be left out when a game is designed in such a way that it is self-sufficient and player can recognize rules and goals by herself, as a part of challenging discovery. Player is thus more active and gameplay can attract him for investigation, for making decisions, and for getting involved.

The activities that take place during gameplay are used less frequent. Their role is to support player when the problems to be solved in a game are too demanding for her or when additional feedback is needed. Different functionalities that are not implemented in a game for different reasons can thus be put into action.

Activities after game play are practically inevitable. Players together with a teacher must have the option to provide reflections concerning their own experiences with the game. This could include reflecting on what they have experienced and learned during gameplay, how they might perform their new skills or use their knowledge, what could be improved upon, and what experiences might have been more useful to their learning outcomes. Gameplay can thus create unique and authentic learners‘ journeys and they find their experience engaging, interactive and therefore memorable.

Kolb‘s Learning Cycle, concept based on experiential learning style theory [Kol84], proposes that the learner39;s opportunity to reflect on her own learn experiences is vital to the learning process. By encouraging learners to reflect on the activities they have participated in, they are no longer just focused on the how‘ of their task or activity but also exploring why they are doing it. The cycle proposes that, for learning to be effective, the learner must progress through a cycle of four stages: (1) having a concrete experience followed by (2) observation of and reflection on that experience which leads to (3) the formation of abstract concepts (analysis) and generalizations (conclusions) which are then (4) used to test hypothesis in future situations, resulting in new experiences. Learners are required to complete each of the four stages.

As it is obvious from a short presentation of the activities that can accompany gameplay, each of them has specific role in learning process and any combination of these activities can be selected to achieve defined learning goals. All these activities are gathered in the so-called pedagogical package, that has to be prepared and offered to teachers who want to use game-based learning for their students.

Whiton [Whi09] identified several external activities that can play an important role in the development of learning package:

- reflective accounts or diaries that students keep of their progress,
- small group work with discussions about gameplay,
- replaying the game and talking through the thought processes involved and how performance has improved,
- production of artefacts that relate to the game (e.g. posters, presentations),
- creative activities around the characters or plot of the game,
- application of skills to the real world through activities that build on skills acquired during the game,
- critique of the game itself and its mechanics, considering how effective it was and how it could be improved.

Serious games by definition must have defined one or more learning goals, but on the other side in must have all the characteristics of game. Prensky [Pre01] has identified seven key elements of the game:

1. The game is based on the story, which provides a framework and connects the parts of the game into a recognizable whole.
2. Players in the game try to meet the objectives related to the story and challenges,
3. While observing the rules that give the game a structure, and add the game some additional challenges.
4. The player participates in the game through active interaction with other persons who appear in the game or within the game environment.
5. They are usually in a conflict relationship, or compete with them.
6. The interaction in the game gives the player a sense of control over events and over opportunities to influence the course of the game.
7. The environment of a game usually responds the player with the outcome or another type of feedback that at any time permits him to verify the appropriateness of his actions and effectiveness of his progression towards the goals in the game.

All these key elements are important as they motivate player and help him to stay focused and to have fun. Additional contributions to educational values of games are sensual stimuli, fantasy, challenge and curiosity (i.e. desire to know or learn).

As we have already mentioned, player is engaged in gameplay in order to meet the objectives of the game. At the same time, he is also directed to earlier mentioned learning goals, which are usually hidden in the game and are not obvious. In this way, we achieve effective learning without the player being aware of learning as he consciously deals only with the goals of the game [Kap12].

Research results show that game-based learning is not suitable for achieving learning objectives in all areas and for all topics. Factors that can influence the appropriateness and usefulness of games for learning are: subject area, selected learning theory and didactic method, taxonomic level of learning outcomes, students‘ backgrounds, students‘ experiences and expertise of the teacher. All these factors strongly influence the selection of the appropriate game genres and their suitability for different concepts [Hoi18].

We focused mainly on serious computer games in the past, but recently also board games and role-playing games are getting more and more popular among students, especially in higher education. We have quite positive experiences with the development and implementation of such games in the teaching and learning process in the framework of Erasmus+ project GameIT: Gamestorming for Innovative Teaching [Gam19].

4 Constructivist Approach To Teaching Computer Programming

Several studies have shown that serious games can support learning with motivation, engagement and fun [Hij14]. Learning programming requires many competences such as logical thinking, problem solving, and the ability to understand abstract concepts. For this reason, many students find computer programing difficult to learn. This fact can lead to low motivation to study introductory programming courses. In order to improve motivation and to enhance students39; learning attitude towards programming, teachers are looking for stimulative approaches to learning.

Programming is best learned by practice and, if students are to learn effectively, at least some of this practice will have to be self-directed or in collaboration with peers. Teacher39;s key role is to persuade students to do this and thus to motivate them [Fel04].

4.1 Trialogical Learning

Constructivist learning theory explains how people acquire knowledge and learn. It suggests that humans construct knowledge and meaning from their experiences and previous knowledge. This explanation sharply contrasts with the traditional understanding of learning where the passive transmission of information from one individual to another was the basis of learning process. Consequently, the focus is moved from teacher to student.

Thus, student becomes active participant in the learning process. She compares her understanding with what she encounters in the new learning situation and if she comes to inconsistency, her understanding can change to accommodate new experience. Student has to remain active throughout this process. She uses her previous knowledge, perceives relevant elements in new learning experiences, considers the consistency of prior and emerging knowledge, and according to this judgment modifies previous and constructs new knowledge.

Teacher's main role in the constructivist learning process is not to transfer knowledge, but to provide students with challenging situations where they can construct knowledge and to provide appropriate feedback, having in mind heterogeneity of students‘ previous knowledge and their mental abilities. Students may need different experiences to advance to different levels of understanding. Learning should take place in the authentic environment or in at least in the environment very similar to authentic one with authentic tasks in order to make learning meaningful. Students need the ability to control the environment where learning takes place and feedback about the activities done. Teachers are also supposed to stimulate communication and collaboration between students using collaborative learning and other different forms of peer interaction.

Learning took place in context. In the past, before massive formal education was set up at the beginning of Industrial Age, people learned with each other in the context of their daily activities, whenever problems and difficulties arose. Mechanistic vision of education saw knowledge as "content some sort of material fluid that could be "transferred from the minds of the teachers into the minds of the learners. Knowledge was broken up into disparate subjects, most of them with little visible application, and started being "transferred, largely by telling and questioning. As this happened, real learning contexts gradually disappeared from education [Fig05]. The mechanistic vision of learning as the "delivery of content still dominates teaching today. We need to take systematically into account interaction and activity, the learning contexts, and the available educational technology to overcome this situation. Part of the future of learning is to be found in the production of content, that can be stored and delivered using technolgy, but a significant part of learning will be found on context. It will happen within activity and interaction rich social environments that the intelligent use of technology is making possible and where completely different paradigms apply [Fig05].

Figueiredo and Afonso defined three concepts:

- A learning event is a situation where an individual learns.
- Content is information that has been structured and encoded as text, multimedia materials, the spoken word of the teacher, or any other means.
- Context is the set of circumstances that are relevant for the learner to build knowledge when referring to content

In such simplified model, the action of the teacher will be seen partly as content and partly as context, and the technological infrastructure will be seen as belonging to the context. This quot;small worldquot; is normally inhabited by other actors, besides the learner, such as colleagues or partners, when the learning event takes place in a classroom or in a community of practice. Many methods currently used in education, such as project-based learning, action learning, learning by doing, case studies, scenario building, simulations, Socratic dialogues, panel discussions, role playing, address issues of learning contexts.

These principles are integrated in the trialogical learning model [Hak09], [Paa05]. The purpose of the trialogical learning design is to focus learning process on different aspects of how knowledge is constructed. Students collaboratively develop, transform, or create shared objects of activity in a systematic way. Trialogical learning concentrates on the interaction through developing these common, concrete objects (artefacts), not just between people as in quot;dialogical approachquot;, or within one39;s mind in quot;monologicalquot; approach.

In the course of learning, joint knowledge is built up and shared among a group of students. Such learning design enables to experience a constant process of development together with concurrent feelings of creativity and success, thereby inspiring one to learn. Combining digital technologies with traditional learning technologies supports the goals of trialogical learning design. Digital tools and other resources help to conduct certain knowledge-based activities better.

Trialogical learning design can be characterized by the following features [Paa14]:

- The activity is organised around certain share artefacts (knowledge objects), that can be idea, phenomenon, rule, principle, goal, or topic. Throughout the learning process, they keep the learners aware of the goals of consecutive activities with artefacts.
- Student, participating in the activity, has to be able to build and share an artefact, discuss it individually or collectively, and reflect on her learning process or on the learning procress of her group.
- The results of student‘s individual creative work with artefacts need to be applied further in subsequent joint activities.

- The activity is organised so that the artefacts are enriched and improved through disclosing the opinions of different individuals and groups, perceiving and understanding a variety of perspectives, and practices of use in respective knowledge communities.

- An artefact can pass through activities, growing richer and maturing from one form of representation into another.

- Activities are supported by a variety of traditional and digital tools that enable to disclose different aspects of the artefact with practices suitable for the particular context.

Students in the introductory computer programming course design and develop programs. This is typical an **active learning** approach. If we introduce project work in groups, which has proven to be a very effective way of learning programming [Nan08], we actually can talk about the **trialogical learning** principle. The trialogical learning plan consists of forms of learning in which students collaboratively develop, change or create common artefact (i.e. computer program in our case) in a systematic process [Kaf95]. It focuses on the interaction that occurs with the creation of concrete artefacts, not just between people (quot;dialogical approachquot;), or within one39;s mind (quot;monologicalquot; approach) [Paa05].

The computer program has, in the trialogical learning sense, the role of artefact, which students have to design and develop to the final product. During the design and development phases the entire process is described in the project documentation.

5 Coding For Girls Project

Coding for Girls project [Cod19] addresses open and innovative education and training embedded in the digital era by targeting programming skills that are high in demand in a technology driven society and by addressing inclusive education offering equal opportunities to girls and boys. The project addresses also the development of teacher competencies and the profile of the teaching profession by empowering educators to effectively build desirable programming skills among their learners by guiding their students in the learning processes by constructing solutions to selected simple problems and realizing them through game design. By appropriate methodological support it can help educators to lead initiatives that promote perspectives of gender equality in the quest for academic or professional paths in science.

As stated by [Spi18], what seems to be a promising opportunity for all pupils to learn coding in an entertaining way raises the question of whether such game based concepts also help to fix the gender gap of women in IT related fields. Gender differences are already present in secondary schools, when career choices and also low levels of participation in technical subjects occur. For this reason, at the University of Technology in Graz/Austria decided to integrate an application Pocket Code, into different school subjects, thus making coding more accessible and attractive to female pupils.

6 Game-Design Based Learning

Students can become more even more active in games based learning when they learn by developing games themselves [Kaf95a]. With appropriate game development tools it can be used for all ages and stages of development. Rieber et al. [Rie98] and Zapusek amp; Rugelj [Zap14] argue that learning by creating games can be more effective than traditional methods.

Game designing assumes that the act of building a game is itself a path to learning, regardless of whether or not the game turns out to be interesting to other people. The idea of quot;learning by designingquot; is based on the assumption that active participation in the design and development process is the best way to learn something. This approach has gained increased prominence due to the proliferation of computer-based design and authoring tools for game design [Rug15].

Constructionist gaming was not part of either discussion in building the field of serious gaming [Kaf15]. But if we want to percieve the potential of serious gaming, we need a broader view that recognizes that opening access and participation in serious games is not just a matter of making better serious games but allowing students themselves to make the games they would like to see and play. Our goal is to promote environments that are good for learning and where there is no strict boundary between player and designer but rather sees them as complementary to each other. Papert envisioned such solutions already in 1998: quot;If one does belong to a culture in which computer games are important, transforming oneself from a consumer to a producer of games

may well be an even more powerful way for some children to find importance in what they are doing.quot; [Pap98].

We implemented this approach in the framework of the two?semester course in the study program for computer science teachers as a project based activity for independent group work. As none of the existing approaches and methods for organizing the process of design and development of educational game from the initial idea to final product, we developed our own methodology, called SADDIE‘ [Rug16].

6.1 SADDIE Methodology For Serious Game Design

Using SADDIE methodology for game-design based learning in teacher education has two important outcomes [Rug14]. The first outcome is a serious game itself. The design and development of a game motivate our students to work actively and to learn in an efficient way through carefully refined process of active engagement in the game design and production process. The second outcome is students39; improvement of the competences that are crucial for teachers. Such competences include the ability to determine learning objectives that are consistent with the curriculum, the selection of appropriate teaching approaches and their implementation in learning process, preparation of feedback, evaluation of acquired knowledge and evaluation of the learning process [Rug18], [Rug14].

The main idea of the project is to combine all didactic and technical knowledge that students acquired during their studies at the faculty and to apply it in a relatively complex project. According to constructivist learning theory, the course has very limited number of traditional lectures. Only the main project requirements are presented by the lecturer in the introductory phase of the project and some general rules about the learning goals and about organization of work are defined. Students then have to follow SADDIE‘ methodology that defines framework phases and other incidental activities.

Students work in groups and are supposed to organize their activities by themselves. They are free to define different types of organizations of work and to accept different roles. Later, during the execution of the project, students in project groups write a log in which they report on the dynamics and organization of the work of the group. By analyzing the logs, we found that in some groups there were exposed leaders and in the others the responsibility was evenly distributed among all members.

At the regular weekly meetings groups prepare oral reports on the work in the past week and on any problems they have encountered. They receive immediate feedback from peers and from the teacher. If difficulties arise, the teacher initiates discussion about what could be the reasons for a problem and gives some hints or suggests possible ways to solve them [Rug18].

The process of developing an educational game requires taking into consideration multiple aspects that regard technology, pedagogy, and domain. This is facilitated by frameworks that serve to inform designers and developers of educational games on what elements should be supported. The availability of such frameworks that provide adequate guidelines for designing and developing games for the educational domain is still considered to be a work in progress [Fis05], [Don07], [DeF06], [Mal14].

6.2 Game Design Based Learning Of Computer Programming

Several authors claim that game programming motivates most students in introductory programming courses. The rationale for this is that because games are engaging and motivational, 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. Courses that use serious games for learning programming have found positive effects on students as well as on learning outcomes [Ate10].

Compelling assignments mean that students are far more likely to learn because they are interested, and the visual component allows students to see mistakes in their code as manifested in the resultant graphics [Leu07]. One strategy proposed for additional motivation for learning of introductory computer programming is the use of Game-Themed Programming Assignments (GTA), proposed by Sung et al. [Sun11].

Kafai [Kaf95] reports that in his game-making project a class of fourth-grade students who programmed fraction games for younger students in their school learned about key computational concepts such as loops, conditionals, and even tail recursion. They also improved significantly in computational practices such as writing and debugging programs when compared to control group of students.

6.3 Programming Microworlds

Programming microworld, a term defined by Brusilovsky et al. [Bru97], is a learner-centred world that can be explored by directly manipulating objects in the world with a limited set of simple commands coupled with metaphors to aid in problem description and to exploit storytelling. This concept represent the first step in the direction to game-design based learning, as microworlds and the objects created inside them can be considered as simple games. Researchers have studied how a microworlds could be used as an educational paradigm [Kel05]. Many different programming microworlds have been used in the last decades for teaching programming of novice students [San03]. Most of them visually represent programming constructs for the easier and more direct comprehension of the most difficult concepts. Additionally, microworlds attempt to introduce students to programming by simulating actual worlds and protagonists and assigning tasks to students, providing a visual overview of their progress [Mal12]. Two of the most significant representatives of such sysytems are Alice and Robocode.

Alice [Coo03] is an interactive programming environment that aims to teach computer programming to students by visualizing objects and their behaviours. Students can use and modify objects in order to create their own virtual worlds and write code for controlling the objects39; appearance and behaviour. Alice utilizes a drag-and-drop smart editor for dragging objects into the editor and for selecting messages to send to an object. User-defined methods and functions are automatically added to the menus. Students can see immediately how their animation programs run enabling them to easily understand the relationship between the code and its result [Pow07].

An interesting programming game, implemented as a microworld, is Robocode, that was designed to promote the learning of Java. Participants in Robocode community are programmers with various levels of expertise and experiences who need to create a robot program. The Robocode framework defines the basic physical rules every robot has to follow and provides a re-usable object structure to ease the development. Participants then compete in Internet- based leagues where each robot tries to search and destroy other robots while protecting itself. Robocode provides a well-defined domain for students to learn and apply concepts of programming and has been implemented in the classroom to stimulate student learning-outcomes [Lon07].

6.4 Game Design In Visual Programing Languages

Scratch is a block-based visual programming language, developed by the MIT Media Lab. Users can create online projects in a cloud using a block-like interface. Scratch encourages the sharing, reuse and combination of code. Users can make their own projects, or they may choose to quot;remixquot; someone else39;s project. An online community has created and more than 39 million projects are shared in the cloud.

It is part of research to design new technologies to enhance learning in formal and informal education settings, demonstrating how informal learning settings can support the development of technological fluency. A number of studies have been conducted to investigate the potential of a number of suggested programming environments for beginners such as Scratch [Oua15]. This introductory programming environment was designed to avoid common beginners‘ mistakes in programming such as syntax errors and logic. It uses visual programming languages based on blocks instead of typing commands. In this context, block is an element of the programming language reperesenting a control structure, an operator, a variable, or a function. These elements can be combined with quot;drag and dropquot; in an intuitive way to construct a computer program.

Scratch allowed beginners to implement animations and games. They can create them from scratch or can just modify another game that can be found in a cloud. Students became familiar with the programming concepts without worrying about syntax. Games, created in these environments, increase students‘ motivation for programming and allow them to develop their knowledge.

Kafai [Kaf15] claims that in the original conception of constructionist gaming, learning of coding and other content were seen as mutually beneficial to each other engaging in knowledge transformation. In the early 1980s Papert‘s success in introducing the foreign concept of computer programming to K-12 schools came from his use of the grounded or practical approach to explain code. Kafai reproted also another important learning benefit in game making that goes beyond learning coding and content: the idea of children learning about their own thinking and learning, also called reflection or metacognition.

Findings from pair programming confirm earlier work on the importance of peer pedagogy in learning coding and project design [Nan08]. Success of learning both coding and content through peer-to-peer collaborative game making has inspired the integration of such activities into the regular curriculum.

6.5 Game Design In Other Programming Languages

Reynolds and Caperton [Rey11] present an educational pilot program of game design in Flash offered in high schools and colleges. The program provides a guided, inquiry-based in-school curricular program for computer-supported collaborative game design, construction, and sharing to participating schools. It is based on constructionist, situated learning and social learning systems principles for the game design and development.

Schools offer the game design classes to students as an elective. Participating schools are offered professional development trainings for educators, Flash software licenses for students enrolled in game design classes, an open source game design course syllabus and curriculum, a wiki-based environment for students‘ online collaboration, code sharing, and game publishing, and a suite of targeted free game design tutorials.

The program is based on a co-learning model where students and educators learn together. Learning interactions include self-led learning in which students and educators learn individually through their own independent game design creative process, peer-to-peer learning, in which students learn from other students, expert-guided learning where game design experts help scaffold learning and help solving problems on demand through live trainings and e-conference sessions.

Students were satisfied as they learned Flash by means of relevant and appealing activities. Some of them claimed thay had problems with programming as it is was difficult and time consum. Another problem they faced was lack of teachers experiences in programming and consequently especially novice programmers lack guidence and were frustrated.

Al-Bow et al. [AlB09] presented thier experiences from two weeks Summer Game Camp for high school teachers and students where they learned programming in Java through game design. The evaluation of results showed that game creation approach to teaching intorductory programming engaged high school students in programming and also increased their interest for computer science topics. They improved significantly their programming knowledge and their self-confidence. The authors believe that teaching game creation as a holistic discipline integrating also art and design makes the approach compelling for the students.

7 Gender And Specific Characteristics Of Games

Women are the largest under-represented groups in computer science. As with the increasing impact of computer science comes the responsibility to ensure that the technologies our society creates meet the needs of all of its members, we need to involve a representative sample of the population in the creation of new technologies.

A number of reasons have been identified a variety of factors that contributes to girls‘ low enrollments in computer science. Among them are disinterest in computers, lack of encouragement from peers, parents, and educators, and relatively fewer opportunities to interact with programming [Kel07] Many of them are not directly associated with computer science, but programming which represents a gateway to to the study of computer science can be make less terrifying and more motivating for girls.

A programming environment that presents programming as a means for creating animated movies (i.e. storytelling) or simple games can be suitable for girls as most of them can come up with an idea for a story or simple game they would like to create [Wol09]. Both are naturally sequential and are unlikely to require advanced programming concepts immediately, they are a form of self-expression and provide girls an opportunity to experiment with different roles, and non-programming friends can readily understand and appreciate an animated story or game, which provide an opportunity for positive feedback. Kelleher, Pausch, and Kiesler [Kel07] used Storytelling Alice and Generic Alice for both cases respectively. They claim that several studies of children programmers have found that when girls and boys have similar experience with computer programming they are equally interested in and effective at learning to program. But programming performance is correlated with the amount of time users spent programming and their prior programming experience.

The results of study carried out by Vermeulen et al. [Ver11] showed that gender differences were consistently present, but previous experience substantially affect the findings. Women are playing games more frequently but shorter periods of time than men. They prefer abstract, short and easy to master games such as casual (e.g. Tetris) and social network games, while men are more likely to play core‘ genres. This category refers to skill-based games which are time-consuming and generally feature high-quality three-dimensional graphics such as shooters, fighting, action- adventure, sports, racing, strategy, role-playing and MMO games. Non-core genres include platform, adventure, simulation, party, serious, classic and casual games. Core genres are played more by males than by females. The study has found that women are fonder of puzzle games, while racing, rhythm, simulation and virtual games are played by both women and men. Another study discovered that women favor party games (such as music and dance games) and classic retro‘ games.

Alserri et al [Als18] made an extensive survey of related papers on effective Serious Game elements, such as motivational elements of digital games players, effective educational game elements, and female preference elements. They used the results to create conceptual model for gender-based engagement in Serious Games. We will use this model in the Coding4Girls project to increase girls39; motivation for programming through the appropriate selection of games that will be designed and implemented by students in game-design-based learning.

The authors stated that the study has revealed that the motivation to play a specific type of digital game depends on gender. The stereotype that females do not play computer games is no longer valid. The differences in gender preferences for digital games, found out in this research, are very similar to the already presented differences, identified by Vermeulen et al. Females prefer explorative and creative gameplay more than males They play more frequently but for less time than men, and their preferences for game genres are also different. Males have been found to spend more time playing computer games than females. Females also prefer puzzle games, social games with rewards offered in the games, educational games, simulation game genres, as well as collaborative, and exploration gaming, virtual life, virtual world, and party games. Moreover, females like to play adventure games, but they prefer to observe others first before playing themselves. The motivation preference elements in gaming for females are challenge, escapism, fun, social interaction, motivation, fantasy, competition, and arousal. Both males and females like racing, simulation, and virtual games.

Phan et al. [Pha12] came to very similar conclusions in their study about gender differences between male and female gamers in terms of computer game usage, preference, and behavior.

8 Conclusions

The learning of programming is accessible not only to higher education students, but it is accessible to others as well. Many programming environments have been developed that can facilitate learning process and many among them support game-based and game-design based learning. The main advantage of such environments is that they foster their users to learn and keep progressing, making programming fun.

We are going to use such programming environments and corresponding methods for teaching and learning in the framework of the Erasmus+ project Coding for Girls to support active, problem-based learning in the context and to introduce early methodological learning interventions that will make computer programming attractive for girls and boys.

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