A Mobile Application for School Children controlled by External Bluetooth Devices

MASTER'S THESIS

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Declaration of Authorship

I declare that I have authored this thesis independently, that I have not used other than the declared sources/resources, and that I have explicitly marked all material which has been quoted either literally or by content from the used sources.

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Abstract

Digital game-based learning as a didactic method includes educational content or learning standards into video games with the objective of engaging pupils. It combines instructional content with computer or video games and can be used as a part of all subjects and ability levels. Exponents of digital game-based learning argue that it gives learning opportunities that involve learners in interactive teaching and advice them to take part in the technological society of the 21st century. The necessity of digital game-based learning came in the last decades of the 20th century when there was a worldwide innovation improvement. Today's learners live their life with access to technology (smartphones, video games, digital music) and the access to this technology results in pupils being smarter, intelligent than their predecessors. This thesis shows the need, motivation, adjustment of digital game-based learning for todays and the future generation of learners by implementing and evaluating a game prototype by pupils aged 9-10. A simple mathematical (multiplication table) game is created to help children practice mathematical skills, where the main intention of the game is to reach fun, logic, thinking, enjoyment, amusement, and light-hearted pleasure. This thesis also includes the connection of smartphones with external bluetooth devices called Flic-buttons, which children use to operate different functions in the game. Children were interested to use mobile devices for learning mathematics especially multiplication table. This means in the same time children tried to achieve positive results and on the other hand they enjoyed the game. Using mobile-based games creates positive mental outlook to pupils toward mathematics, their dynamic participation is more noteworthy and the acquisition of mathematical knowledge, aptitudes is more efficient.

Kurzfassung

Digital game-based learning als didaktische Methode beinhaltet Lerninhalte oder Lernstandards in Videospielen mit dem Ziel, Schüler zu engagieren. Es kombiniert Lehrinhalte mit Computer- oder Videospielen und kann als Teil aller Fächer und Fähigkeitsstufen verwendet werden. Exponenten des digital game-based learning argumentieren, dass es Lernmöglichkeiten gibt, die Lernende in den interaktiven Unterricht einbeziehen und sie dazu ermutigen, an der technologischen Gesellschaft des 21. Jahrhunderts teilzunehmen. Die Notwendigkeit des digital game-based learning kam in den letzten Jahrzehnten des 20. Jahrhunderts, als es eine weltweite Innovationsverbesserung gab. Die heutigen Lernenden leben ihr Leben mit Zugriff auf Technologie (Smartphones, Videospiele, digitale Musik) und der Zugriff auf diese Technologie führt dazu, dass die Schüler schlauer und intelligenter als ihre Vorgänger sind. Diese Masterarbeit zeigt die Notwendigkeit, Motivation, Anpassung des digital game-based learning für die heutige und zukünftige Generation von Lernenden durch die Implementierung und Evaluierung eines Spielprototyps von Schülern im Alter von 9 bis 10 Jahren. Ein einfaches mathematisches (Multiplikationstabelle) Spiel wird geschaffen, um Kindern zu helfen, mathematische Fähigkeiten zu üben, wobei die Hauptabsicht des Spiels darin besteht, Spaß, Logik, Denken, Genuss, Unterhaltung und großes Vergnügen zu erreichen. Diese These beinhaltet auch die Verbindung von Smartphones mit externen Bluetooth-Geräten, sogenannten Flic-Buttons, mit denen Kinder unterschiedliche Funktionen im Spiel steuern. Kinder waren daran interessiert, mobile Geräte zum Erlernen der Mathematik, insbesondere des Multiplikationstabellen, zu verwenden. Das bedeutet, dass Kinder in der gleichen Zeit versuchen, positive Ergebnisse zu erzielen und auf der anderen Seite das Spiel genossen haben. Die Verwendung von mobile-based games schafft positive mentale Perspektiven für Schüler in Mathematik, ihre dynamische Teilnahme ist bemerkenswerter und der Erwerb von mathematischem Wissen, Fähigkeiten ist effizienter.

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Dedicated to my dear grandfather "Brahim Maloku".

Chapter 1

Introduction[1]

Video games as a new field have been in presence for only several years and they have influenced an extraordinary number of individuals as their sales have surpassed those of movies (Olthouse, 2009). They incorporate film, graphics, text, and sound to convey stories and objectives to the player. As a new form of media, video games have the capability to communicate to a wide audience in a unique way (Olthouse, 2009). The assortment of computer games genres addresses their prominence with a diverse audience and playing video games is a particularly outstanding leisure activity for children and young adults (Aldrich, 2005). Video games as a popular approach demonstrate that a large number of kids have a mutual social experience better than the older generation (Aldrich, 2005). Apart from the games designed for entertainment, they contain also some educational features, such as background scenarios (the historical context in a WWII battle simulation), platform, diagnostic abilities, forced moments of reflections, chat rooms, tests and quizzes and mnemonic devices (Aldrich, 2005). Learning from video games, or technology has caused many dilemmas in the sense that they really are creating a new positive potential for learning or simply creating dependencies. Generally, video games are thought of as a good opportunity to improve memory and develop thinking skills. Since many studies have shown positive and negative effects, this issue was also raised by author Neil Postman in 1993 (Postman, 2006), which lists a range of questions about what we really get from technology, whether it is beneficial to learning or the opposite. For many educators, the role of games in learning is already considered

[1]Parts of this chapter have been published in:
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epic, especially in self-learning or the so-called metacognition effect, which requires the players to understand systems. These systems include a wide range of elements related to each other (symbols, signs, mathematical systems) that put the individual ahead of the next challenges, help build skills for solving problems and develop perceptive abilities.

The main intention of the thesis is to support and motivate children to learn multiplication table in new ways. The research interest focuses on the following two research questions:

- **How can seamless learning be effective using innovative devices for learning mathematics?**
- **What can be concluded from the evaluation of the learning activity in a third school class?**

To answer these questions as mentioned above, a simple math game using external devices is implemented which brings together a combination of motivating elements, such as enjoyment, pleasure, engagement, challenge, intense and passionate involvement, and emotion. This game is evaluated from pupils in the secondary school, which shows the instant need for specific educational games and their available motivational aspects. In addition to this introduction the structure of the work contains other five chapters and an appendix and as follows:

- *Chapter 2:* introduces the state-of-the-art of the game-based learning like adoption of the games for learning, why this approach is successful, effectiveness, what can children learn from educational video games, the importance of mobile technologies in the learning process of children, innovative technologies for education and learning, and children's perspective on mathematics and game playing.
- *Chapter 3:* in this chapter there are summarized many results and opinions from different research papers about the importance of the game aspects in the learning process, such as domain, format, context, feedback, interaction, motivation, enjoyment, engagement etc.
- *Chapter 4:* explains the design and technical aspects of the prototype's implementation.

- *Chapter 5:* shows the evaluation of the project from pupils in a secondary school.
- *Chapter 6:* shows the results of the evaluation and importance of game-based learning for pupils.
- *Appendix:* contains the documentation of the game, that means the structure of the program's classes.

Chapter 2

State of the Art[1]

This chapter is divided into four sections, where the first one outlines the game-based learning as a different approach from other ways in developing children's knowledge. The second one introduces the mobile-based learning, thus how mobile technologies are changing the way children learn. The third section explains some innovative technologies for education and learning and the last one describes the children's perspectives on mathematics and game playing.

2.1 Game-Based Learning

> Play is our brain's favorite way of learning things.
>
> Diane Ackerman

Educational games are those deliberately intended for the purpose of education, or which have unexpected or optional educational value. According to an article (Maricel Rivera, 2016), most of the people need effective and interactive experiences to actively participate in the learning process and one of the approaches to achieve this is through game-based learning. Generally, game-based learning involves the use of computer and video games, and it is designed to balance subject matter together with gameplay, where the learner absorbs and practices the acquired knowledge to the real world. As children

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play, they learn to solve problems, they work to achieve a goal during activities, from which they get experiences. While children make mistakes, the game environment allows failures to become challenges, which then encourage children to improve their movements until they arrive at the correct way of doing things. Several authors have come up with definitions of digital game-based learning (DGBL). For example for (Mayer and Johnson, 2010) a DGBL environment should feature:

- a set of rules and constraints
- a set of dynamic responses to the learner's actions
- appropriate challenges enabling learners to experience a feeling of self-efficacy
- gradual, learning outcome-oriented increases in difficulty

Computer and video games (Prensky, 2007) are extremely impressive learning tools which can create effective new learning opportunities for children in early age. In this section, there are explored the learning dimensions of computer games, which help to clarify the relationship between computer games and learning and they help children to learn more effectively in the future using computer and video games. The section interest focuses on the following three research questions (Prensky, 2007):

1. Why game design and adoption is needed as vehicles for learning "serious" content and subject matter?
2. Why learning already happens when a pupil plays a computer or video game designed purely for entertainment – whether consciously or partially or totally unbeknownst to the player?
3. How learning games are design and how games create rigorous learning of given academic or training material?

2.1.1 Why Use Games for Learning?

There are two reasons, for which children want or need to use computer and video games for learning real-world scenarios and subject matter.

- Pupils have changed radically – during the development of digital technology (computer and video games), it has changed the way pupils think and process information and these changes have affected their intellectual style and preferences (they have very different minds from their parents) (Prensky, 2007).
- Pupils need to be motivated in new ways – computer games can provide a new way to motivate pupil to learn, where motivation is really important since learning requires putting out effort (Prensky, 2007).

However the things that are used in the past to motivate learners do not motivate the learners of today and fortunately, now new computer games play a major role in shaping the preferences and abilities of learners, and they are the biggest learning motivator ever seen (Crawford, 1984).

2.1.2 How Learners have changed

Today's students represent the first generation to grow up with the digital technology and they spent their entire lives surrounded by and using computers, video games, digital music players, video cams, cell phones, and all the other tools of the digital age. It is evident that as a result of this digital environment and interaction with it, pupils think and process information differently from their predecessors and these differences go further than most educators suspect or realize. As Dr. Bruce D. Berry (Baylor College of Medicine, 2001) says: "Different kinds of experience lead to different brain structures". As a result of how pupils grow up, it is very likely that their brain has physically changed and is different from those of their parents, where (Prensky, 2007) have found a designation from them called *Digital Natives*.

2.1.3 Why it works

Nowadays, the reason that the pupils play games is because the process of game playing is *engaging* (see Fig. 2.1). These games bring together a combination of motivating elements not found in any other medium.

Computer and video games:

- are a form of fun, which gives pupil enjoyment and pleasure.

- are a form of play, which gives pupil intense and passionate involvement.
- have rules and goals which give pupil structure and motivation.
- are interactive and adaptive, which give pupil doing and flow.
- have outcomes, feedback and win states, which give pupil learning and ego gratification.
- have conflict, competition, challenge, opposition, problem-solving, characters and story, which give pupil adrenaline, social groups, emotion and spark their creativity.

FIGURE 2.1: Pupils using new technology during lesson. Image downloaded from http://www.themessenger.global/2017/04/09/how-technology-can-help-children-learn/ (2017, April 9).

Based on these factors combining games and learning can possibly add highly motivation of the pupil to learn, and increase their engagement in the learning process. During the interaction with digital technologies, children start the learning process, which gives them relaxation and enable them to put forth effort without displeasure. As is stated in a book (Crawford, 1984)

"Children are expected to play because we recognize the fundamental utility of games as an educational tool".

Games engage and motivate children through their goals and when the children sometimes struggle to achieve them through the opponents and challenges they have to overcome, through the emotions and connections with others they feel when playing, then this interaction make them spending a lot of hours before their computers and consoles. The careful combination of all this engaging power of computer games with a set of interactive learning processes is what produces digital game-based learning.

2.2 Effectiveness

The benefits of game-based learning have never been systematically demonstrated, although many studies (Erhel and Jamet, 2013) have investigated the effects of them on learning process and motivation. In this section, there are described some findings from different scientists, which report the transfer of cognitive processes that are engaged by playing specific computer games.

- (Green and Bavelier, 2003) – did some experiments, in which they compared the visual abilities of subjects who had played few or no games for six months. Four of the experiments explain improvements in different indices of visual attention for the players compared to controls, while the fifth one explains the improvements in visual abilities among neophyte players, compared to their pre-playing abilities.

- (Greenfield, Brannon, and Lohr, 1994) – found a correlation between video game expertise and performance on a mental paper-folding test, but limited video game practice had no effect on paper folding. Structural equation modelling found that video game expertise, developed by self-reported deep-routed playing, had a beneficial effect on performance on the paper folding test.

- (Hung, Huang, and Hwang, 2014) – developed a mathematical game-based learning environment on e-books for helping children reduce mathematical anxiety and improve their self-efficacy, motivation, and achievements in learning mathematics. An experiment with 69 pupils

is developed on an elementary school math course to evaluate the effectiveness of the proposed approach. One class was assigned to be experimental group A (23 students), another class was experimental class B (23 students), and the third was the control group (23 students). In the experimental process, the three groups took pre-tests, had experimental instruction, and then took post-tests. The experimental results show that the game-based e-book learning model effectively promoted the students learning achievement, self-efficacy, and motivation of mathematics.

- (Subrahmanyam and Greenfield, 1994) discovered that play on a computer game (Marble Madness) among fifth and sixth graders improved spatial performance.The spatial representation consists of skills such as mental rotation, spatial visualization, and capability to deal with two-dimensional images of a two- or three-dimensional space. The logic of the Marble Madness game is that players are required to guide a marble along a three-dimensional grid, skills that are key components of visual-spatial tasks.

- (Prensky, 2007) describes Click Health (founded by National Institutes of Health), which made games to help kids self-manage their issues and they concluded: in the case of diabetes, kids that playing their games show much more perceptible achievements in self-efficacy, communication with parents, and diabetes self-care.

- (Prensky, 2007) illustrates a game-based program called Fast ForWard, which retrained kids with reading problems administrated from National Field Trails (60 professionals at 35 sites across the United States and Canada). Based on the standardized tests, each of the 35 sites reported the effectiveness of the program, in which 90 percent of the children improved a lot in one or more tested areas.

2.2.1 What Players learn from Playing Computer and Video Games

(Olthouse, 2009) studied the relationship of children with video games especially the attention of children to concepts of "fun" and "learning". In the context of video games motivation and learning are discussed , as well as

the question is asked "Can an experience (like playing video games) be both fun and educative?" Video games are an almost new media, which have attracted both negative and positive attention from scholars, where some of them see video games as an indication of educational paradise, saying "the young people of today understand instinctively that their games are their very best teachers". The existence of video games is known since 1980 by affecting a great number of people as the number of video games sold has exceeded the number of movies (Olthouse, 2009). Video games tend to combine film, graphics, sound, and text to impart stories and intention to the player, which are drawing from previous forms of media, including symbols, spoken language, early writing, and manuscript. Video games differ from other media in many forms:

- Video games offer significant interactivity with the player.
- Video games recommend sporting elements to the media, which include reaction times, strategy and competition. The justification for that is simple: video games encompass frequent pauses in the form of directives to the player (find this object, battle this opponent, solve this puzzle). In this interactivity the role of the player is crucial in the development of the storyline, and affects the storyline, because the player is compelled to respond in many ways in order to achieve and advance the storyline.
- Video games posses the ability to adjust the players learning capacity by relying on the computers artificial intelligence, where players have the freedom to gain more successes than they might have if they were playing a board game against someone, who is more advanced. In this context the major role play feedbacks, because they keep children engaged longer from the progress they did. The impact of the feedback and reinforcements makes kids spend a great amount of time with this media.

Video games are primarily designed for entertainment but they also contain some pedagogical features and this features of games include background scenarios, scaffolding, diagnostic capabilities, debriefing, forced moments of reflection, libraries of successful and unsuccessful plays, chat rooms, test and quizzes and pop-up prompting (Aldrich, 2005).

Because of importance of video games to teach, many scientists and game theorists see a hopeful role the intersection of video games with education

(Gee, 2003; Prensky, 2007) and they argue that the structure of today's video games see certain types of learning as essential and beneficial to students, especially metacognition, computer skills and perceptual skills.

Players figure out how to learn by playing video games and one of the methodologies in which video games teach metacognition is by requiring players to understand systems. Numerous computer games depend on a systems model (symbols systems, value systems and mathematical systems) and factors inside the game associate as indicated by predetermined rules, rules the player must find and comprehend to wind up plainly effective. To tackle the complicated problems, which the systems give, players may need to separate enormous problems into littler steps, master an arrangement of subskills, or go through various progressively difficult levels. In this way, players discover that going up against a challenge involves separation of it into littler steps. Additionally, players learn the metacognitive skill of constancy through challenges and in many games, achievement relies on searching for clues, requesting for advice, and attempting an assortment of procedures. Moreover, players learn through different character deaths, that mistakes might be fundamental for progress (Aldrich, 2005).

2.2.2 Known Risks of Digital Game-Based Learning

In the article of (Olthouse, 2009) apart from the advantages of digital game-based learning also the things that kids should take away and negative effects (long time standing in front of video games, graphic violence) are explained. Other factors of video games (aggressive content, depressed imagination, and monetary issues) have generated a long list of possible problems (Anderson and Ford, 1986). For example an aggressive content could affect the behaviour, thoughts, problem-solving styles and social skills of children. While children play video games for a long time, they could be addictive and spend their school lunch money or money stolen from their parents with the purpose of making fast and positive progress in arcade games (Anderson and Ford, 1986). As a disappointing fact, this kind of games and also home video games are considered as one of the top three causes for family violence in USA (Meinel, 1983). From the experiment results, (Anderson and Ford, 1986) concluded that depending on the amount of aggression in games, these games can affect negatively player's emotional state. For example if the amount of aggression is highly involved in the game, then this could increase

the hostility and anxiety to the players, while if the amount of aggression is medium then this could lead only to hostility of the game players. An article written from Hema Gopalakrishnan[2] points that the enormous use of games can lead to negative effects where players tries more to win than to learn, employees do not focus on collaboration (unnecessary rivalry among them to win badges and medals, which are essential pieces of games) and insufficient participation and sharing of thoughts. Also another important thing mentioned in this article is content of the game, where sensitive topics, for example, sexual harassment is not suitable for a game-based learning topic. This means the context of the game is really significant where the lack of it leads to a failure to capture the learning objectives.

2.2.3 The Future of Digital Game-Based Learning

The eventual fate of digital game-based learning is expected to be a splendid one, where by 2025, there will be nobody left the education system (student, teacher, or administrator), who has not played computer games basically all the life (Prensky, 2007). There will be a lot of choices and styles of learning games for every subject and these choices will give children the opportunities to decide which learning game they want to play to handle the material. Taking into account the future (Prensky, 2007) defines four of future elements:

- The future of digital learning – the new technology is going through a huge "building and construction" stage innovatively. Many companies and schools have the ability to investigate and grasp choices or augmentations to classroom learning. The number of online courses every day is going to increase and further simulation is playing a major role in the online training process.

- The future of digital games – where is the games industry going? (Prensky, 2007) claims that the certain and precise answer for that is almost impossible because the game industry is a new business in the market with a lot of rapid, scalable changes. It will exist an opportunity to create photorealistic 3D freely and the new generation of games will have better special effects as today's movies. New displays (huge and

[2]https://blog.commlabindia.com/elearning-design/game-based-learning-limitations-prevention. Retrieved (2018, April 25)

smaller) will permit players, 360-degree vision, so the game's 3D virtual worlds will be occupied by players from all around the world. The physics of the things (move, reaction, speed) will become more realistic and players will really be inside the universe of the game. The game modes will be extended as much as possible so the players can use any of them:

  - single-player
  - one-on-one
  - multiplayer modes

  Most of the games will be played around the world online, by teams in the same room or arcade with enough broadband capabilities (with the help of portable devices accessing in wireless). Artificial intelligence will be improved in such a way that it will allow the creation of more realistic characters and interactions. The subject of the game will be expanded and the companies including writers, artists and authors will create games with different themes, educational stories, which will give the players amazing emotions. The quality of games will be increased from the fact that people will learn how satisfying entertainment is and this quality will be the same as in movies or other consumer products.

- The visions for digital game-based learning – one of the excited digital game-based learning vision is to have games and learning so incorporated that the new game promptly turns into a learning tool. Since the distinction between the customer market and the education market is as yet solid, this vision is further away but the indication of progress exist. A few organizations are making learning games shells and offering engines, other companies present their learning games, from SimCity to Start-up, as a consumer as opposed to instructive products and some other organizations possess both games and learning divisions. (Prensky, 2007) describes also the vision as a phenomenon to integrate all teachers and students together to multiplayer games, where learning can be always happening, students evaluated, and scores looked and classified. Persistent multiplayer games similar to *EverQuest*, *Asheron's Call*, *Ultima Online*, and *Star Peace* will merge with the new learning administration systems to make only these sorts of digital game-based learning environments.

- Challenges – Game-based learning can be expensive and takes a lot of time. In any case, as companies show update in game design, other players will most likely need to purchase game subscriptions. This memberships can be costly and are normally obtained every year, where some of them require a game console rather than the computer, so the children would need to buy enough game consoles for their classroom. The greater part of the children know how to play computer games, however not in the context of school and it will take time to help the pupils to exchange their learning from a video to the classroom setting. One of the major challenges is how much teachers are interested in learning how to integrate game-based learning into their classroom. (Marzano and Pickering, 2010) gives a few recommendations for teachers while choosing games for the learning environment:
  - Teachers should use insignificant rivalry.
  - Competition is natural, but teachers should keep the stakes low.
  - Teachers should also target the essential academic content.
  - Teachers should ensure that the goals of the games listed with the goals of their lesson.
  - The students should revise the work after playing the game and this allows children to exchange information gained from the game back into the classroom.
  - Teachers need to ensure they are not having their children play a game just to have them play a game
  - Teachers should provide objectives and goals, which are lined up with the game.

2.3 Mobile-Based Learning

Mobile devices such as laptops, tablets, e-book readers, mobile phones and personal digital assistants have turned into a learning tool with enormous potential in both classrooms and outdoor learning(see Fig. 2.2). Concerning access to PCs, large-scale programs have been implemented in numerous countries comprehensively to such an extent that elementary-school and middle-school students and their teachers possess their own mobile devices.

Further, regarding innovation's promotion in education via information technology, mobile computing support conventional lecture-style teaching, and also
through advantageous information assembling and sharing it can promote creative teaching, for example, cooperative learning, exploratory learning outside the classroom and game-based learning. Along these lines, mobile technologies have extraordinary potential for encouraging more innovative educational strategies (Sung, Chang, and Liu, 2016).

FIGURE 2.2: Different mobile devices. Image downloaded from http://edtechlead.net/2014/03/28/here-and-now-mobile-learning/ (2014, March 28).

Regarding the article of (Zucker and Light, 2009), the authors believed that school programs that incorporate laptops into school, affect positively on students learning. However, they also emphasized that the accomplishment of the goals of expanding higher-level thinking and transformation of classroom teaching techniques is not based on the laptop use. As far as this is concerned (Penuel, 2006) looked into 30 studies that analyzed the use of laptops with wireless connectivity in coordinated PC programs and those studies found that students regularly used the laptops to do homework, take

notes, and complete assignments. In the other hand, (Bebell and Kay, 2010) analyzed four different experimental investigations of laptop programs in schools and they found that in many schools participating in one-to-one programs there were huge increments in grade-point averages or standardized tests of student accomplishment, in respect to schools that did not give such programs. They found also that most students used their laptops to browse the Internet, write, do homework, make presentations, or take tests. Besides that, teachers made more improvements to their techniques when they had expanded opportunities to use laptops.

2.3.1 How Mobile Technologies are changing the way children learn

Children have always loved playing with each other, running around, running at the beach or playing hide and seek in the woods. These days, the things have changed in the way that children possess mobile technologies in their pockets so that they can do more than simply enjoy the moment. With today's technology: digital camera, smartphone or iPod, they can take pictures or record sounds, they can tag these artistic creations with comments and other personal details and then share them to Facebook or another social websites (Druin, 2009). In terms of this, a specific roleplay handheld tools such as digital devices, which are changing the way children explore and relate to their particular area. For instance, they can measure the level of carbon monoxide, which is emitted from their school bus and they can compare their results between each other. These are only a couple of cases of manners by which the new generation of mobile technologies is changing the way children learn. Mobile technology helps children unavoidably by providing novel ways of relating their physical experiences to abstract knowledge, from playing together outside to understanding what a carbon footprint is. Handheld computers[3] may become a progressively convincing decision of technology for classrooms since they empower a progress from the periodic, supplemental use related with computer labs, to continuous and necessary use of portable computational technology (Roschelle, 2003). Based on the article of (Vahey and Crawford, 2002), the authors stated that teachers and students should react to handhelds positively. For instance, 90% of teachers in an investigation of 100 classrooms declared that handhelds

[3] https://en.wikipedia.org/wiki/Handheld_PC. Retrieved (2018, January)

were successful instructional tools with the possibility to affect student learning positively over different topics and instructional exercises. (Roschelle, 2003) in her article provides details regarding the use of classroom, or lecture room response systems. An educator poses a short multiple-choice question and each student chooses an answer on a handheld device like a TV remote control. The system immediately gathers all student's responses and presents them in a histogram. Despite the fact that the form of response is limited, adopters have shown how the devices can bolster formative assessment, enabling the teachers to evaluate the learning of individual students and the general understanding-level of the whole class. Educators can demand pupils create virtual study groups using mobile devices to share or to ask academic information. With numerous social applications accessible, it is very easy to connect students using mobile devices. Normally, few children are really shy and they do not want to connect with others in the real world, therefore they may find it less difficult to connect virtually. Based on that, it is much easy for teachers to spot these pupils and they create a group of children, which share the same mobile device in the classroom or outside the classroom (see Fig. 2.3). Children learn easier when they get examples and illustrations from fellow pupils. So as an educator it is crucial to blend ingenious learners with slow learners (Karheka Ramey, 2012) [4]. The importance of mobile devices can also be emphasized by helping many children to correct their issues with proper grammar, it will help them write grammatically correct sentences effectively and learn quicker (spell checks). If the classroom is computerized and each pupil has their own device, the educator can illustrate lessons in a visual format, this will help children who are visually inclined.

In the article (Ng'ambi, 2005), it is described an experiment in the University of Cape Town, where students in large classes are able to provide individual responses using SMS (Short Message Service). Students can submit anonymous questions by SMS. This is added to a website, where other students can see the question and they can respond to it. After a few moments, an email notification is sent to the tutor and the tutor responds to the given questions, sent back the answers to the student's device and also all other students can see it on the website. In this way, the students are able to gain pieces of information from other student's questions and the tutor

[4]Ramey, Karehka. (2012, December 10). *The Pros And Cons of cell phones in schools*. https://www.useoftechnology.com

FIGURE 2.3: Children in peer to peer computer discussion. Image downloaded from https://www.useoftechnology.com/pros-cons-computers-classrooms-2/ (2012, November 7).

gets important feedback about the student's difficulties. In a similar way, (Markett et al., 2006) was able to check the SMS by students in real-time, via their personal mobile phones. The professor was able to see messages and respond during class, where these messages were also available online after the lecture, allowing discussions between students to further develop their knowledge.

2.3.2 Mobile Learning Activities

(Druin, 2009) describes four types of activities in relation with mobile applications:

- Physical exercise games – During the years mobile technologies have been focused on various physical activities to support children's understanding of conceptual phenomena. In relation with there are give some examples, where (Scarlatos, Dushkina, and Landy, 1999) describes FloorMath, which incorporates a sensor-embedded floor mat with a visual portrayal of numbers that shows up on a screen. At the point when kids move along on foot up and down the squares, the relating numbers change on the screen. So the activity becomes more important by walking the numbers, which this helps children to see and comprehend abstract concepts in a new way. Furthermore, another example by (Scarlatos, 2006) called SmartStep, requires children to play hopscotch, skip, and count in the meantime while practicing fundamental mathematics abilities. This combination of physical and mental activities is intended to improve motor abilities, pattern recognition, rhythm, and coordination. It is worthwhile to mention that Nintendo Wii applications are beginning to be used for learning different physical and subjective skills. It is founded that playing Marble Mania [5] improved the finesse abilities that are required for performing surgery; All these applications use mobile innovations to help physical activities (For example: walking, running) with learning mathematics, physics, or other cognitive skills.

- Participatory simulations – (Colella, 2000) describes the definition of participatory simulation as a game in which sensor-based devices are used or carried by children to establish a complex phenomenon, such as epidemiology. Every child plays the role of an element (for example, a virus) at ground level that they see at bird's-eye level to perceive how their individual engagement influences the entire system.

- Field trips and visits – The authors (Roschelle and Pea, 2002; Rieger and Gay, 1997) describe another important use of handheld technologies to expand children's field trip and visits to museums and other different places. In this context, the mobile devices give historical, environmental, or social data about what is being observed that is applicable to the progressing movement but that is not accessible in the environment. The arrangement of such informations helps children to build up their investigation skills. An article from (Rogers et al., 2004) was the first

[5] https://en.wikipedia.org/wiki/Kororinpa. Retrieved (2018 April 19)

one that described this approach to mobile learning. This article illustrates a field trip with a difference, where children (10-12 years old) had to explore a forest and at specific circumstances, access, find or get significant sources of digital information using a collection of embedded and mobile technologies. It is worthwhile to mention one case with a special examining tool that the kids used to gather real-time measurements that appeared in simple visualizations of light and dampness levels being shown on a PDA (Personal digital assistant) screen Fig.2.4. The children were impressed from the tool and they examined numerous parts of the forest, where they explored extreme measurements: children try to locate the wettest and driest parts of the brightest or darkest parts, where the results they checked on the PDA. In the wake of taking a reading, the kids would propose to each other alternative places to go to affirm or disprove their hypothesis about the readings they were getting. Generally, this activity involved children making suggestions about what readings they expected to get and then testing predictions about environments. As a conclusion the learning exercises that occurred in the article "Ambient Wood" were impressive. Coordinated effort and self-directed requests forms were much in evidence. Specifically, the kids used the mobile devices to make predictions, generate hypotheses, and analyze their data.

- Content creation – Another researcher (Bruns et al., 2007) in his article emphasized the importance of mobile learning to create a content in the appropriate place, for example, story composing and filmmaking. From that, the basic idea is to empower the development of narratives that reflect events in which the children have been engaged, for example, a visit to a city, or a zoo. This procedure involves gathering, sending, sharing and representing information, such as photos, notes, and audio, among groups of children in one of the mobile web applications (Facebook, Twitter, Flickr). As a main advantage of the creation of content is children's opportunity to take photos and to record different parts of the appropriate place and this activity influence them to choose applicable information that is related personally or to the task, record it, and then represent it through distributing it in the Internet or demonstrating it in class. This requires making a rich form of narrative that "tells a story" around the children's recorded materials, which can enable them to make associations between different activities.

FIGURE 2.4: Pupil using PDA to measure the level of moisture. (Druin, 2009)

2.3.3 The Benefits and challenges of Mobile Learning

(Hashemi et al., 2011) describe in their paper the reflections on what mobile learning has to offer and to consider whether it is likely to change how dialects are taught and learned. Educative practice is not dictated by technology, nor is technology to be a deciding factor in informal, regular learning. They illustrated the benefits and disadvantages of the mobile learning, as showed in the Tab.2.1.

2.4 Innovative Technologies for Education and Learning

Various new communications technologies have emerged lately that have been largely observed and designed for individual and recreational use. However, these new technologies and learning tools coupled with the power and reach of the Internet, have made them practical options for both educational

TABLE 2.1: The advantages and disadvantages of mobile learning devices (Hashemi et al., 2011)

	Advantages	Disadvantages
1	Children interaction with teachers and among each other	Small screens of mobile phones and PDAs
2	PDAs are lighter than books and enable children to take notes or input data directly into the device	Limited storage capacities in PDAs
3	Numerous children can work together on assignments even while at distant locations	Battery life/charge and less robust
4	The new generation prefers mobile devices such as PDAs, smartphones, and game devices	Lack of common operating system and of hardware platform
5	Control of the handheld devices increases commitment to using and learning from it	Still difficult to use moving graphics and limited potential for expansion with some devices
6	Handled devices are accessible to a larger percentage of the population because they are more affordable than larger systems	Devices can become out of date quickly
7	Handheld devices increase work/learning performance and relevance to the learner	Wireless bandwidth is limited and may degrade with a larger number of users
8	Handheld devices may assist learners with some disabilities	Difficulties with printing unless connected to a network

learning and knowledge-based applications. In this section several different technologies and uses will be explained, such as instant messaging (IM), Weblogs (blogs), wikis, and podcasts (Hsu, 2007). The enthusiasm in exploiting these sorts of innovations arises from the unique pedagogical advantages gained, as well as from the essential need to remain tuned with the focus and strengths of today's students. In the article of (Prensky, 2007), the author recommends that the students being taught today are *"no longer the people our educational system was designed to teach"* and that while today's students can be named *"digital natives"*, numerous teachers could be better-named *"digital immigrants"*. The motivation behind this section is to examine these technologies and investigate both the evolution of their use from personal applications to that of educational tools and furthermore to look at the key educational applications for which these are being used.

2.4.1 Instant Messaging (IM)

Instant messaging allows interactive and real-time synchronous communications with immediate response, where the main features of it combine both its synchronous nature and its ability to support chat and phone-like interaction. It includes the major systems, such as Kik Messenger[6], Yahoo! Messenger[7], and ICQ[8]. Some of the remarkable features of IM incorporate the ability of the users to see user details as to current status (online, away, idle, out to lunch) and also on a user's changes in status (active, logged out, etc.). Any contact can be made when wanted through the screen, in which the lists of users are displayed. If a "chat" is initiated, a special window is showed and the interaction can begin, gave that the two parties are online and willing to continue (Hsu, 2007). In the article (Nardi, Whittaker, and Bradner, 2000), researchers have concluded that instant messaging is ideal for spontaneous interaction. Specifically, the IM's use has been shown to be essential in the situations where collaborative coordination and problem-solving is involved. IM is in particular useful in specific communications circumstances, since it has a tendency to be less disruptive and interfering, while in the meantime a client's accessibility is more obviously known. Furthermore, it is convenient

[6]https://en.wikipedia.org/wiki/Kik_Messenger. Retrieved (2018, April 10).
[7]https://en.wikipedia.org/wiki/Yahoo!_Messenger. Retrieved (2018, March 19).
[8]https://en.wikipedia.org/wiki/ICQ. Retrieved (2018, April 19).

means for setting up more formal interactions, such as arranging a conference call.

There are explored and tested many aspects of the educational use of instant messaging. IM not just allows students to collaborate together more productively on homework assignments and projects, but also helps to manage a closer social network between students, which could positively affect learning. Additionally, the use of instant messaging may really help and encourage deeper and more dynamic learning, if instant messaging is rigorously targeted and focused toward proper material or lecture topic. The authors Cifuenetes, Carpi, and Lents in their article (Lents, Cifuentes, and Carpi, 2010) describes that in studying subjects, such as biology course IM could encourage students to approach their professor with certainty and also expand their interest and achievement in their examination.

TABLE 2.2: Summary of Instant Messaging (Hsu, 2007)

	Instant Messaging
Advantages	Accessibility and acknowledgment by students, Social presence, Real-time (synchronous) communications, Encourages teamwork, Reduces formality in communications
Disadvantages	Distracted attention, especially in a classroom setting, Time waster, Expectations of 24-7 professor access, Time consuming for educators, Benefits are uncertain in classroom settings
Educational applications	Virtual office hours (professor-student), Association on group projects, Real-time class discussions, Mentoring
Course/subject suitability	Courses with group projects and assignments, Distance learning support

2.4.2 Blogs (Weblogs)

Blogs began as methods for expressive people to post online journals of themselves. These blogs were basically an individual's online narrative or journal, with events, stories, and opinions. While its original use was for individual expression, currently its viability as a tool for education has been found, including its use as an expansion of "learning logs" which are made on the web (Barger, 1997). The Weblogs's use can be considered new, but the concept of keeping a "log" or "learning log" is not. The notion of "learning logs" also called electronic portfolio (ePortfolio) has been in use since before the appearance of the Weblog, and the concept of this is to empower somebody to document his or her learning, to do some critical reflection as well as self-investigation. Based on the article (Dyrud, Worley, and Flatley, 2005), the researchers described that the use of electronic Weblogs as educational tools offers the advantages of increased information sharing, simplified publication of pieces information, and improved teacher monitoring and review. (Walker, 2003) defined that blogs as *"frequently updated Websites consisting of dated entries arranged in reverse chronological order"* and can take a few models, including:

- The personal journal/diary – comprises details about someone's life and thoughts.
- Knowledge-based logs – capture learning and places it online in different formats.
- Filter blogs – strives to select, rate, or remark on data contained in different sites.

The educative uses of blogs exploit their capacity to encourage expression and the advancement of online connections. Online journals take into consideration learning and interaction to be more knowledge-centered, particularly if the assignments are organized in the form of empowering feedback and contribution from the instructor and other experts. Furthermore, blogs enable students to gain a better perception of a subject's knowledge sphere. In the article of (Glogoff, 2005), is explained an example of this kind of blog-enhanced class structure, where students may be given a Weblog from which to finish numerous course assignments. After the student makes researches in the designated subject, he would present the new information by "publishing" it to the Weblog. After the assignment's publication, this description can

be reviewed and critiqued by the instructor, as well as by different students in the class. This kind of assignment and association would be particularly helpful for both hybrid and fully online distance learning courses. (Betts and Glogoff, 2004) point out other important benefits of Weblogs, which could be expressed using learning approaches and conceptions of:

- Guided discovery – takes into consideration the investigation and study of a specific topic, which is then followed by assignments that emphasize the blend of information. As a result, a student can be requested to investigate an area and "constructs knowledge" using the Weblog as a medium. They are able to post and make comments about other student's blogs, and this procedure gives an atmosphere of interactivity and collaboration. One of the benefits of using blogs together with guided discovery is that it reinforces the use of cognitive scaffolding, where students would approach learning by constantly seeking information, reflecting and considering what has been realized, and afterward going back and getting more relevant data, in order to expand upon and dig further into the subject area.

- Directive learning – responses from students are followed by encouraging feedback from professors, and can likewise be supported using blogs. For this situation, students would use a blog to submit assignments, as well as to review professor feedback.

- Receptive learning – instructional modules have introduced that emphasis on certain more extensive areas, from which numerous sub-areas within these are highlighted for a student to research and report on.

- Social-centered instruction – is a logical component of educational work using online journals, and specifically the use of peer and social interaction as a piece of learning procedure. The use of blogs functions as an effortlessly medium for students to present their discoveries and also to incorporate the information presented, as well as related links and references to different resources. This type of association helps to facilitate more investigation by students.

TABLE 2.3: Summary of Weblogs (Hsu, 2007)

Weblogs (Blogs)	
Advantages	Reflection and critical thinking are encouraged, Social presence, Development of a learning community, Active learning encouraged, Ability to receive and respond to feedback
Disadvantages	Controlled primarily by blog author, especially in a classroom setting, Editing/modifications not open as in a wiki
Educational applications	Online learning journal, Problem-solving, Online gallery space (writings, portfolio, other work), Mentoring, Peer review exercises
Course/subject suitability	Writing courses, Research seminars, Foreign language courses

2.5 Children's Perspectives on Mathematics and Game Playing

Throughout time it seems that games have reflected numerous aspects people's life, such as culture (values, interests, and activities) and anthropologists have studied interesting games played by ancient people, in respect to their opportunity, place, and environment. Games help people bring together and they enable them to practice and enhance their skills, challenge their intellect, and enhance their capacity to solve problems (Griffiths and Clyne, 1995). Games are believed to be fun, guaranteeing full engagement, especially through reflection and discussion, on which productive learning depends. It is generally expected that games will inspire students, resulting in more willing engagement and enhanced the learning of mathematics (Booker, 1996). The main focus of this section is the relationship between games and children reactions to mathematics, where a key factor is the capability of games to stimulate motivation through enjoyment and achievement.

2.5.1 The Benefits and Effectiveness of Games for learning Mathematics

In general, it is obvious that game playing is beneficial and it has been recommended that children learn through social interaction (talking, listening and collaborating) and the mathematical games are important for stimulating and empowering mathematical discussion between groups of children and amongst pupil and teacher. Based on the article of (Abrams, 2009), technology and the use of computer games can expand students' knowledge, lead them to make more relations between subjects, and enable them to form an individual relationship with the subject they are studying. Abram describes also how three students who play video games could put material from their classroom and make it important to them. Other authors Liu and Chu in their article (Liu and Chu, 2010) illustrated how integrating games into English program accomplished better learning results and better motivated students over strategies of teaching English without using games. The authors demonstrate based on their discoveries that the students that used games-based strategies as a factor for learning in many areas including test scores, attention, confidence, satisfaction were more successful than the students who did not get game-based teaching strategies. (Booker, 1996)

expressed that favourable position of playing games with peers is the immediate feedback children get. Children can explain and clarify their absence of mathematical comprehension. While children playing a game, they have made clear the prediction, testing, generalizations, justification of decisions and control of the procedures of the game.

Middleton and Spanias have shown in their article (Middleton and Spanias, 1999) that American children have a tendency to enjoy mathematics in the primary grades but that this level of satisfaction tends to fall dramatically when children advance into and through high school. Moreover, in spite of the fact that students feel mathematics as an important subject, the number of students who need to take more mathematics in school is declining consistently. These facts appear to be disturbing when combined with the way that children do not have mathematical knowledge that they will need to function easily in the today's technological society. To resolve these problems (Middleton and Spanias, 1999) described theoretical orientations guiding exploration in mathematics motivation. They delineated two types of academic motivation:

- Intrinsic motivation – happens when students take part in learning for its own purpose and they enjoy it.
- Extrinsic motivation – happens when students learn with a specific goal to secure a reward (good marks, favourable opinion from others or to avoid parental disapproval).

They recommended that a major effect on motivation is the impression of students of how successful they are in the mathematics lecture and to what they attribute that success. They need to feel that achievement in mathematics is determinable to their capacity and exertion. (Bragg, 2003) tells that motivation is a general issue in mathematics because of society's acknowledgement of poor attitudes about the potential for progress in mathematics. Based on the observations about motivation (potential connections between mathematical games and motivation, the advancement of positive attitudes and achievement) that L.Bragg did in her article (Bragg, 2003), she created a model, which is illustrated in Figure 2.5.

In essence, according to this model, it is suggested that motivation plays a crucial role in student learning and there are numerous factors impacting motivation (attitude and success in the maths lecture). The students who are

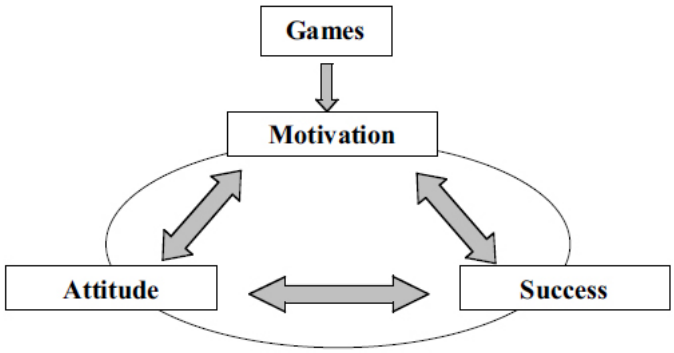

FIGURE 2.5: The role of games in motivation, attitude and success. (Bragg, 2003)

interviewed by L.Bragg were able to express both positive and negative experiences related to mathematics games. The characteristics related to the positive experience were seen to be having a sensation of success, a capacity to engage with exercises effortlessly and take part in an enjoyable activity. The games are seen as fun as well as children would have the chance to participate in meaningful dialogue about the mathematical concepts and techniques underpinning the games. They should be confident to share strategies and ideas through the entire class and one-on-one discussion.

Chapter 3

Math Learning Games

In this chapter many results and opinions from different research papers about the importance of the game aspects in the learning process are summarized.

3.1 Composition of Gameplay and Learning

> One wonders whether there is any limit to what can be done in merging the addictive elements of computer games with effective instruction.
>
> Bob Filipczak

An enthusiasm for the use of video games for learning has emerged and various cases are made as to the viability of games in education. The educational games are considered as new instructional innovation with great power and in the previous chapter are described numerous cases, in which the significance of educational games for learning is emphasized. The intention of this section is to summarize the aspects of the educational games, which affect the learning processes. In the article (Vandercruysse, Vandewaetere, and Clarebout, 2012), the authors made efforts to find an exact evidence of the expected advantages of games and to exhibit which aspects or elements play a role in creating games adequate for learning. They stated also that the connection between game aspects with particular learning results (in order to accomplish learning objectives) would seem advantageous

for educators, practitioners, and the learners themselves. Thus, this exploration inquiries for this section are:

- Which components can be considered as unquestionable in an efficient educational game?
- What are the specific and important factors that impact the effectiveness of a game?

3.1.1 Content/Domain

Based on the discoveries that researchers did in their article (Vandercruysse, Vandewaetere, and Clarebout, 2012), applications of games in education are various and the results that they get demonstrate that games are used as a part of an assortment of domains, for example, science, mathematics, history, geography, etc. The content model characterizes the learning constructs of the games and takes out what levels of proficiency may look like in learners. From various perspectives, this is the core of a learning game, since it profoundly defines the essence–without which, one can not be sure as to what the game is actually addressing. This is a fundamental aspect that is generally easily addressed when designing a learning game (Cesa-Bianchi and Lugosi, 2006). Aspects include:

- Description of the core construct
- Deconstruction of the parts of that construct
- Descriptions of capability

3.1.2 Format

Given the collection of domains, it is not unexpected to find an assortment of games used as a part of different investigations, such as multiplayer educational game applications, computer-based video games, computer-based role-playing games, virtual reality educational games etc. Again the question can be made whether generalizations from investigations with one type of game can be constructed to investigations using different sorts of games and a problem here is that nonspecific topology of game sorts exists. This makes it hard to understand what authors mean when using particular terms for sorts of games.

3.1.3 Gaming context

Two authors Ke and Grabowski in their article (Ke and Grabowski, 2007) studied the impact of a coordinated goal structure on fifth-grade students' mathematics efficiency and attitudes, compared to an interpersonal competitive and control group. Students were arbitrarily assigned to a four-member team and they initially got time to collaborate with their colleagues and then expected to compete as teams against each other. They played games against the computer and their individual scores were analyzed against others in the class through a ranking list. The control group got just drill and practice sessions in mathematics that targeted similar abilities taught in the other two groups. From that researchers demonstrated that the gaming context plays a crucial role in moderating the effect of educational gaming on affective learning results.

3.1.4 Game elements

According to (Vandercruysse, Vandewaetere, and Clarebout, 2012), games are usually not described in a reasonable and comprehensive way which makes it hard to distinguish game elements without a far-reaching explanation. Additionally, the mix of various elements makes it difficult to understand which aspects are important for results. As a result, the authors of (Vandercruysse, Vandewaetere, and Clarebout, 2012) verified which game elements were already considered in observational research that they did and which conclusions could be drawn in regards to the instructive effectiveness of these different elements.

- Content – An experiment was performed by (Goodman et al., 2006), and the authors wanted to decide if game content affected learning acquisition through game-play. There were compared two groups of students, where one group played a game in which concussion symptoms were realized, and other group got a game that did not contain this content. The results obtained demonstrated that the disclosure of concussion content through a computer game improved the recognition of concussion symptoms and an expansion in the speed of identifying these symptoms. The second experiment, which is performed by (Brown et al., 1997), investigated whether an interactive video game with diabetes-related content affected the self-care and medical results

among youngsters and youths with diabetes. The treatment group, that worked with the content-rich game, presented relative to the control group, gains in self-efficacy, communication with parents about diabetes and diabetes self-care behaviour. The interference had no impact on the blood test results. In whole, the two studies demonstrate that the groups that played the games containing the important content beat the control groups.

- Feedback – comes when something in the game changes in response what children do and it is what children mean when they say computer games are intuitive. Feedbacks tell children immediately whether what they have done is positive or negative, whether they are remaining inside or breaking the rules, moving closer to the goal, and how they are getting along versus the opposition (high score table) (Prensky, 2007). Feedback plays an important role in a game-based learning. Children learn constantly how the game works, what the designer's basic model is, the manner by which to succeed, and how to get to the following level and win. An experiment from (Moreno and Mayer, 2005) has to do with an interactive multimedia game and this game was realized in science classes. It was explored how varieties of *guidance* (some pupils got a clarification why the answer they pick was wrong or right, while others did not) and *guidance* (some pupils were requested to clarify the appropriate response they chose, others were not) affect learning. Results demonstrated that guidance as exploratory feedback created higher transfer scores, less wrong clarifications and more reduction of misconceptions during problem-solving.

- Interaction – (Prensky, 2007) describes two important aspects:

  - Interaction of the player and the computer
  - Inherently social aspects of games, children do with each other

  As (Prensky, 2007) stated, play promotes the formation of social groupings and it is much more fun when children play with others. This is the reason why in pre-computer games the kind of "solitaire games" is tiny compared to games that are played with others. Regardless of the business underlying focus on single player games or games against the

machine, the tendency of actual computer games is to become multiplayer. Like the Net, computer games are really bringing children into closer social interaction.

- Competition – in the article (Yu, 2003), the author analyzed the mediating impacts of anonymity and proximity aspects in an online synchronized team rivalry learning environment in the classroom. He analyzed three conditions:
  - Face-to-face team rivalry – students in this team rated considerably less positive on inner-group processes than those in other two conditions.
  - Decreased proximity team rivalry – students in this team rated between other two teams.
  - Anonymity team rivalry – students in this team rated considerably more positively on classroom than other two conditions

  In overall, rivalry in games seems to have an effect on the classroom atmosphere and students behaviour.

- Background music – (Vandercruysse, Vandewaetere, and Clarebout, 2012) investigated whether music (changes in pitch and tempo) expands learning. There were formed five groups with respect to various combinations of tempo (slow-medium-fast) and pitches (low-medium-high) of three given soundtracks. As indicated by (Vandercruysse, Vandewaetere, and Clarebout, 2012), changes in pitch and tempo had no huge impact on test scores. When the soundtracks were compared with each other, a crucial differential impact was found between the first soundtrack and the control group, so students working with the first soundtrack beat the students in the control group. Furthermore, the researchers reduced their concentration to one treatment group compared to one silence control group. The outcomes demonstrated that no important difference between the background music group and silence group, and this implies no real interference between background music and learning outcomes was found.

- Display system – In (Richards et al., 2008) is investigated the impact of display systems on the feeling of immersion, where a distinction

was made between a *Cone display* and a *3-monitor display*. A statistical important difference was found in favour of the 3-monitor solution. The researchers specify cognitive overload as a significant component to take into the consideration.

3.1.5 Moderating variables

- Gender – as (Prensky, 2007) states, gender is an issue particularly on the minds of game makers, and exactly one that people should remember especially when they think about digital game-based learning. There are many debates and discussions about computer games and gender. Based on different papers that (Vandercruysse, Vandewaetere, and Clarebout, 2012) investigated, there are some important characteristics about games and gender as follows:
  - At first, numerous fewer girls than boys played computer games. Many individuals, including computer games makers - girls after all represent half their potential group - have been attempting to take care of this for quite a while.
  - Little disagreements about these things are changing and that more women play computer games, where the issues are how much and how fast.
  - Numerous observers think the proportion of women playing computer games has changed impressively in the last several years as girls have more access and are more convenient with computers and video consoles.
  - Always there have been girls and women who like computer games and (Prensky, 2007) investigated how women play an assortment of video games in a highly engaged way (Devil Dice to Golden Eye, Unreal Tournament).
  - They found out whether the amount of change of knowledge scores in the experimental group was unsurprising from various student attributes, including gender. Contrary to that, (Ke, 2008) is justified why he considers gender important. He claimed that gender has an important impact on access and participation in gaming environments and practices. (Ke, 2008) used among different variables, gender as moderating learner aspect. Another study by (Ke

and Grabowski, 2007), which were focused on the efficiency and attitudes of students when researching the moderating gender impacts. It was not found any main effect of gender and no important interaction effect between treatment and gender on mathematics efficiency or attitudes.

- Age – the investigations that (Vandercruysse, Vandewaetere, and Clarebout, 2012) performed include different age categories (from 8 to 56 years old). Especially, little consideration is given to the possible differences among various age groups. (Goodman et al., 2006) reported different age groups namely 11-12 years, 13-14 years and 15-16-17 years. Important essential impacts for age classification were found for learning acquisition and on completion time, where (Goodman et al., 2006) also found that the enthusiasm for the game appeared inversely proportional to age. Based on these results, educational games are thus played by students of any age and the age appear to have an influence of the interest, completion time and knowledge and subsequently ought to be born as a primary concern in further research.

- Playtime – the authors in (Beale et al., 2007) investigated the rapport between the number of hours the treatment groups played and their achievement in composing activities. The magnitude of learning turned out to have no relationships with the recorded hours of play. However, the amount play time appeared to have by any way an impact because larger effects were acquired from similar analyses when the non-players were avoided from the group that did play the game frequently. Another research from (Fontana and Beckerman, 2004) investigated the amount of time that students play a game and they found that the amount of play time related with accomplishing high scores and with an energy about emotions, respect, and behavioural approaches.

- Motivation – Based on the article of (Ebner, Holzinger, and Catarci, 2005), motivation can be considered as a moderating variable since the assumption is usually made that motivation affects the learning performance of students because it influences a student to invest more energy in the learning content, makes them focused, etc. In the studies from (Vandercruysse, Vandewaetere, and Clarebout, 2012), the obtained results about motivation demonstrated that students in the game playing groups were more motivated than the others, they were more excited,

seemed extremely concentrated in the task and showed high levels of engagement.

3.1.6 Learning Outcomes

- Attitudes – in the article (Ke and Grabowski, 2007) is researched the effect of game playing on the fifth-grade student's mathematics attitudes and found a general important effect of game playing. The authors also found the impact of computer games on positive attitudes toward mathematics learning. Another study from (Fontana and Beckerman, 2004) analyzed whether an instructional computer game is a feasible way to teach violence prevention and whether such a game could influence students to build up an appreciation of pro-social convictions, attitudes, and behaviours that are pointed out in the interactive innovation materials. Based on that, the outcomes demonstrated essential changes in students attitudes about human behaviour and other situations.

- Enjoyment – is frequently observed as one of the most important reasons to realize games in educational settings. (Vandercruysse, Vandewaetere, and Clarebout, 2012) tells that students like playing games for educational purposes and additionally when students found the opportunity to play games without educational purposes, they also demonstrated a high amiability. From that, it is concluded that, instead of educational games, games as such heighten the likeability.

- Engagement – (Vandercruysse, Vandewaetere, and Clarebout, 2012) analyzed the engagement for the history of mobile city game by scrutiny. The data demonstrated that all students playing the mobile city game were actively engaged. They also measured engagement by the protocol for classroom investigations. There existed differences in the level of engagement of the members while interaction with a computer game, where the students in the experimental group were more engaged than control group students (without games).

3.2 Mobile Educational Games

Numerous scientists demonstrate the efficiency of using educational games in the learning field. Thanks to the new wave of mobile technology, these games became even possible to run on mobile devices. This section will outline two mobile math learning games tested and played on a mobile phone.

3.2.1 Kids Math - Math Game for Kids

This math game (see Fig. 3.1) is really educational, funny and challenging for kids. It offers three different modes to train addition, subtraction and the combination of addition and subtraction. In the main screen it provides the main buttons for each of modes and also three additional buttons: Help button, Like button and Sound button. If the player presses the "Help button" it will be opened a new window which teaches the player how to play in the game.

FIGURE 3.1: A game activity of the first playing mode "Addition", the random question with different colours and the three solution possibilities in the bottom of the screen. (2017, August 7). Image downloaded from https://play.google.com/store

So it is generated a math question with possible solutions and it gives the player visual instructions how to drag and drop the answer to the required

field. When the player press one of the play mode buttons then it will be opened a new window, in which the player can select different levels: (0-10, 0-20, 0-50, 0-100). The first level generates the questions between 0 and 10, the second one between 0-20 and so forth. As is shown in the Fig.3.1 the player can select one of the answers and drag it to set in the right position. Every level contains maximum 15 questions and when the player finishes them, he will the proper stars related to his success.

3.2.2 Multiplication games

Using this math game (see Fig. 3.2), kids can learn better the multiplication table and consolidate the knowledge gained at school. This game is separated into two parts: Play Now and Times Table section. The interface of the application is really careful designed, so the player can make navigations without any problem, and enjoy the learning phase. In the Times Tables section, the player can find the multiplication property until ten, so one can navigate from one form to another by learning bit by bit. When the player selects Play Now section it will be opened a window containing three difficulty levels: Easy level, Intermediate level, and Hard level. Each of these levels comprises of a series of questions and children can know for himself immediately if their answers are correct or wrong by pressing the buttons and based on that they will have the chance to change their answers pressing another number or going to the following question.

FIGURE 3.2: A game activity of the "Play Now" section, where the random question with different colours is generated and the three solution possibilities in the bottom of the screen. (2018, January 11). Image downloaded from https://play.google.com/store/

Chapter 4

Prototype[1]

In the preceding chapters, there were defined and introduced key terms like game-based learning, mobile-based learning, and other important innovative technologies. This chapter seeks to gather the entire aspects of previous chapters theory with a concrete illustration. This chapter, in general, explains the main features of the game including design, various configurations, and technical implementation.

4.1 Overview

1x1 Trainer Flic is a learning application for kids and the best option to learn the whole multiplication table (from 1 to 10). It's a cool math app for children to learn in an easy and progressive way at home. The focus of the game is guessing the right answer, so the question is given combined with the answer (it doesn't mean that the answer is correct) and the player have to choose, whether the answer is right or wrong.

4.1.1 Main Concept

1x1 Trainer Flic is an educative application dedicated to children, in which the player tries to learn the multiplication table by giving the right answers. The interface of the app is created as simple as it has been possible to enjoy

[1]Parts of this chapter have been published in:
Valdrin X. Maloku, Markus Ebner, and Martin Ebner (2018). 'A Mobile Application for School Children controlled by External Bluetooth Devices.' *International Journal of Emerging Technologies in Learning (iJET), in Review*

the learning phase and it is designed in the simple way to make the navigation for the children so easy. The application is divided into two parts:

- Play
- Trainer

In the Play mode, the player doesn't need any registration or something like that, he/she can freely open the levels (multiplication table) and give his/her answers. In the Trainer mode the player has to be registered (to open a new account) and then the learning process will be tracked.

4.1.2 Focus

The main focus of the game is the seamless interactivity of the user with the game for learning multiplication. When running this application, the user should have fun and at the same time, he/she could practice the multiplication property. Children can check their progress: in the offline mode they can see their performing results in the table and based on the results they can overcome their mistakes to achieve great performance, in the online mode their progress will be saved on the server, but also they can check it in the table in the same way as in offline mode. This is really important because it will take time until the player solves mathematical questions without any mistake and it keeps the player for a long time in front of the mobile/tablet trying to give the best. In this way, the learning process will be easier, relaxed, and crucial for the development of mathematical knowledge.

4.2 Flic Button

The intent of this thesis is also the use of external Bluetooth devices, which provide the interactivity between player and the game. For that reason, there are used some smart buttons called Flic[2]. One can place this button anywhere and click to trigger over 40 applications and features in the phone: from ordering an Uber to set an alarm to playing music. Flic recently used open APIs[3] to add Wink[4] Shortcuts to that List. There are few examples that

[2]https://wiki.winkathome.net/Flic_-_The_Wireless_Smart_Button. Retrieved (2017, April 26)

[3]https://partners.flic.io/partners/developers. Retrieved (2017, Jun 2)

[4]https://en.wikipedia.org/wiki/Wink_(platform). Retrieved (2018, March 17)

demonstrate the importance of the Flic button, which make life a little bit easier:

- Let us assume the user has a "Welcome Home" Shortcut setup that turns on the lights, alters the thermostat, and puts the camera into the Home mode. One can place a Flic on an auto dashboard, connects it with the Shortcut, and presses it when one pulling into the driveway for a more advantageous arrival home.
- Another example: when the user is in bed ready to sleep and it has a "Goodnight" shortcut, but the user left the phone plugged downstairs. It can place a Flic on the bedside table, press it when the yawning becomes unavoidable, and the home will power down.

Why does the user need the Flic application? The fliclib works with the Flic application so the user does not need to worry about taking care of the Flics, scanning the Flics, or checking the communication with them. All of that is taken care of by the Flic application.

- User needs to download and install the Flic app. It is free and it can be found in the Google Play Store [5].
- User need to connect all the Flics to the application.
- After the second step, the user is able to use the Flic Grabber and get access to the Flics inside the application.

As is shown in Fig. 4.1, Flic button contains three functionalities to trigger events: Single Click, Double Click, Hold. How to import the fliclib into the project in Android Studio will be described in the "Implementation" section.

[5]https://play.google.com/store/apps/details?id=io.flic.app. Retrieved (2017, June 1)

FIGURE 4.1: Flic Button. Image downloaded from https://flic.io/shop/flic-4pack (2017, November).

4.3 Gameplay and Game Elements

It's a matter of integration.

Michael Allen, Allen Communications

A specific educational content, simple design, satisfied navigation are key concepts of the outstanding performance of a game and as such, they affect the association between learning and the game. As (Prensky, 2007) stated, there are three reasons why digital game-based learning is important: *engagement* (the process of putting the learning into a game context), *interactive learning process* (different forms based on the learning objectives), and *the cooperation of two processes above in an entire container*. From the results of experiments that (Ke and Grabowski, 2007) obtained, the data shows that the effect of game playing (mathematics attitudes, engagement) on the fifth-grade

students and they found a general important effect of game playing. The authors also found the impact of computer games on positive attitudes toward mathematics learning. Other authors in their article (Hung, Huang, and Hwang, 2014) have explained how they developed a mathematical game-based learning environment on e-books for helping children reduce mathematical anxiety and improve their self-efficacy, motivation, and achievements in learning mathematics. The experimental results have shown that the game-based e-book learning model effectively promoted the students learning achievement, self-efficacy, and motivation of mathematics. These effects (mathematics attitudes, engagement, enjoyment) are tracked also in the evaluation with children, where from the experimental results the majority of children realized more than 85% of all questions positively in the first round and when they repeated the game stage for the second time they improved more by giving even better results. Children found the game motivated and considered it significant to interconnect something completely external (Flic button) to the learning process. Another effect that is worthwhile to mention is the balance principle of the game design, where (Prensky, 2007) identified the balance as a player feeling that the game should be challenging but fair, and not to be difficult nor to easy. To answer this, two main concepts are taken into account in this thesis:

1. **Algorithm:** an algorithm developed by (Schön, Ebner, and Kothmeier, 2012) is implemented, which selects the adequate questions as well as it classifies the given answers. Based on the properties of the algorithm (difficulty of the exercise, degree of competence) which are described later in this chapter, the generation of the question should not be difficult nor too easy (for the first time, it generates a random question). From the experimental results, children expressed different opinions, where some of them seemed the generation of questions a bit difficult, while the others found it balanced.

2. **Assistance:** There were implemented different encouraged facilities called Jokers which try in one form or another to give the user a guidance. One of the disadvantages of the video games is that they offer additional helping services, which are costly. While children play video games for a long time, they could spend their school lunch money to make fast and positive progress in games (Anderson and Ford, 1986). To avoid these negative issues, the concept of the game is determined

that everything should be free and the design of the game should not contain something that has to do with payments. From the experimental results, it is considered that children were interested in the role of Joker (Default Joker, Magic Bomb, Magic Star, Magic Heart, which are described later in this chapter) and they used it for every question to see in the end how many outcomes were correct and wrong.

In the following sections, there will be described the visual aspects of the game and there are also many questions that this chapter tries to answer: How is the game structured? How are levels organized and designed? What are the options the player seeks to solve problems? How does the game end and how the results are displayed? How can auxiliary clowns help the user to solve the problems?

4.3.1 Splash Screen & Main Menu

The splash screen contains the main logo of the application, loading simulator and also the version of the application. The main menu consists of four buttons: Play, Trainer, Credits, and Exit as depicted in Fig.4.2. The first two buttons contain the main structure of the game. That means children can play by solving mathematical questions (multiplication). The difference between them is as follows:

- Play Mode (Offline) - the user can access this mode offline and one can practice the multiplication property in the game activity. The user's performance will be saved in the local database so that the user can always check his progress.
- Trainer Mode (Online) - in this mode it is required a registration or an authentication in *"https://schule.learninglab.tugraz.at/"*, then selection of one of the levels, selection of other features (Settings, Joker shop, Statistics), and it will be displayed the game activity. The performance of the user will be traced by the server and also it is saved in the local database so that the user can see his performance. It differs from other buttons in colour so that the user can discern to join the learning process.

The third button is about the credits of the application: who wrote the code, who made the design, who managed it and so on. The last button is called Exit and its purpose is to close entirely the application.

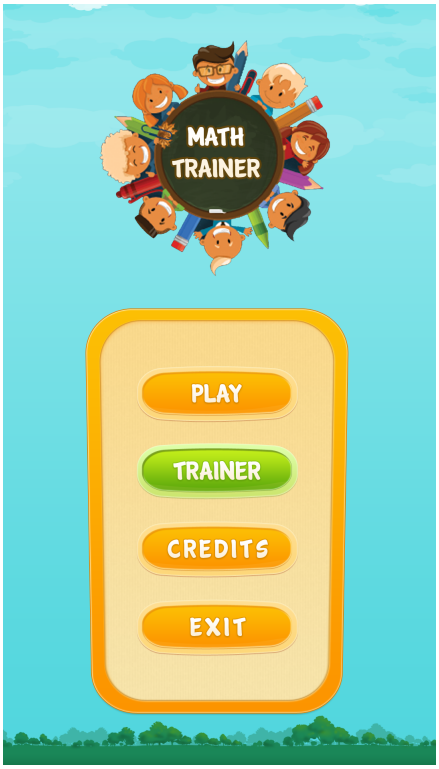

FIGURE 4.2: 1x1 Trainer Flic: Main Menu

4.3.2 Level Structure and Features (Joker, Settings, Statistics)

When the user clicks on Trainer Mode button then it will be displayed a window containing the login screen (this part will be described in detail in the "Implementation" section). In this part the user can register his/her account or log in with the proper credentials and this process will be continued to the levels activity Fig.4.3.

The levels are defined as buttons in the way that the user can select one of them, each button encompasses an inscription (proper number) in it and the multiplication table in relation with the mentioned number. That means when the player clicks the button with number one, then the all the questions are of the form (random generation of questions): **[1 x 1, 1 x 2, 1 x 3, ... , 1 x 10]**

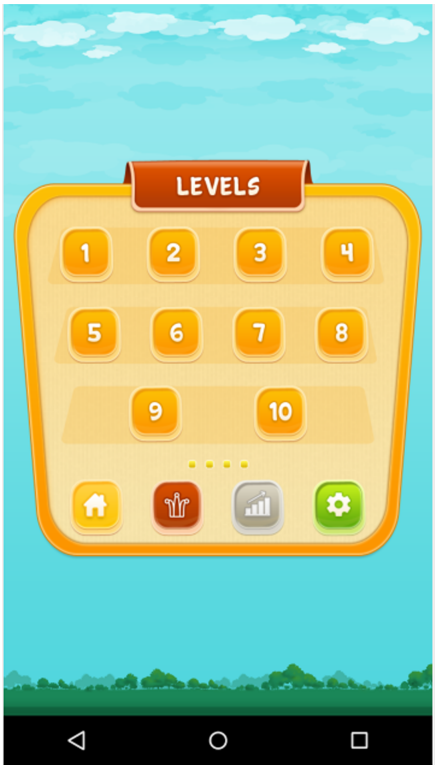

FIGURE 4.3: 1x1 Trainer Flic: Levels Activity

Despite the level buttons, this activity consists of other important features, which are described as follows:

- ***Home Button*** – when the user clicks the Home button then it will be opened the main menu.
- ***Joker (Shop) Button*** – there are different helping approaches called Jokers which try in one form or another to give the user a guidance. There have different properties and also different cost.
  -  **Magic Cap** – this joker differs from all other jokers by colour because is a default one and it is also free. That means that the joker helps the user by giving the right/wrong question with probability of 50%.

-  **Magic Star** – this joker helps the user by telling the right question five times and to unlock it, one needs to gain 150 coins by guessing the right question (one right answer correspond to one coin). After this limit the user can not use it anymore.

-  **Magic Bomb** – this joker helps the player by increasing the number of coins (+10) after five right answers in row

$$number\,of\,correct\,answers\,\%\,5\;==\;0$$

  After that it will showed an animation called Ripple Animation to warn the player to press the joker. If the player does not press the Joker Button than it will loose the bonus coins. As a precondition to unlock this joker, one needs to achieve 350 coins.

-  **Magic Heart** – this joker helps the user by resetting the time from the beginning. To unlock this joker the player needs to gain 550 coins.

- ***Statistics Button*** – in the statistics activity there is a table which consists of four columns (an example Fig.4.1): As one can see from the Table 4.1 the first column includes the names of the levels. This differs from the table in the Play Mode, such that in that table the first column contains the names of the users. For every unique ID that will be attached when the user is logged in, the performance of it during the levels will be saved in this table. This means if the player chooses one of the levels and get the results from the guessed answers, then these results (correct answers, incorrect answers, time) will be stored in the database and will be displayed in the table. There all totally 25 questions and the time depends on the difficulty selecting by the user. If the difficulty is "Beginner" than the time always will be 30", otherwise the time is different for every level as follows:

- ***Settings Button*** – this control panel enables the user to configure actions in the application (also called preferences, tools, options). There

TABLE 4.1: 1x1 Trainer Flic: A table which contains the data about player's statistics

Name of the level	Correct answers	Wrong answers	Time
Level 1	15	10	30"
Level 6	7	18	12"
Level 4	13	12	16"
Level 10	22	3	18"

TABLE 4.2: 1x1 Trainer Flic: A table which contains the different seconds per each level (Advanced Settings)

Nr. of levels	1	2	3	4	5	6	7	8	9	10
Seconds per level	30	28	26	24	22	20	18	16	14	12

are three possibilities, which the user can arrange: turning the music on/off, then configuring the appearance of the Joker (on/off), and changing the difficulty to beginner/advanced.

4.3.3 Gameplay

This is the core of the application in which the user can exercise the multiplication property. This window is separated into three layouts as shown in Fig.4.4. The first layout lies in the upper side of the window, the second one in the middle and the third layout lies on the bottom side.

- First layout: In this layout, there are two buttons (Back button, Sound button) and three widgets (time per question, the number of collected coins and the total number of questions). There are strictly defined 25 questions per each level regardless of the choice of application difficulty. When the user clicks on the back button then the navigation will go one step back exactly in the Level menu. In the sound button, the user can turn on/off the sound of the application. The time per question can be assigned in the Setting mode. It depends on the difficulty mode, that means when the player changes the difficulty to "Advanced" the time will change, as shown in Table 4.2. For every right answer, the user will gain proper coins and these coins can act as possibilities to buy new Joker modes.

- Second layout: In the second layout a question for the user will be showed. The question is given combined with the answer, but does not mean that the answer is correct (it is generated randomly). Also in this part, there are implemented some particle effects for given both types of answers correct/incorrect.

- Third layout: The third layout encompasses three buttons: Right button, Wrong button, and Joker button. When the user considers that answer is correct, he/she can click on the "right" button and otherwise on the "wrong" one. The third button (Joker) is dedicated to help the uncertainty of the user. The buttons can be pressed also by using Flic buttons. As mentioned in "Flic Button" section, the button contains three functionalities: Single Click (is dedicated for the right button), Double Click (is dedicated for the wrong button) and Hold (is dedicated for

Joker button). There are some kinds of Jokers which are described in the Shop category.

FIGURE 4.4: 1x1 Trainer Flic: Game Activity

After the end of each level, the user can see the actual number of coins, the proper seconds of each level and the number of stars he earned. At the end of the "Level Complete" window, there are four buttons: Repeat (when the user is not satisfied with the number of collected coins or stars one can repeat every level how many times he wants), Home (it will be opened the main menu), Joker (the window in which the user can buy one of the Jokers modes) and Next (in the next button the user can traverse through the next level):

4.3.4 Credits

When the user clicks on the Credits button in the main menu then it will be opened the new window in which is described an acknowledgement of those who participated in the production of the project.

4.4 Implementation

4.4.1 Development Environment

1x1 Trainer Flic application is implemented in Java in the integrated development environment *Android Studio*, **Version 3.0.1**. The minimum API Level is Android 4.4 'KitKat' **(API level 19)**. Additionally, there are used some libraries as follows:

- Flic Library - can be used to create custom functionality for flic buttons. The player can use flic buttons to take control of his apps without having to fumble with the phone every time he/she wants to do something. Basically, Flic functions as a remote that gives the player the power to execute actions through the smartphone, without using his smartphone.
- Leonids Library - is a particle system library that works with the standard Android UI.
- Android View Animations Library - is used to perform tweened animation on Views.
- Android Ripple Background Library - performs a beautiful ripple animation.
- KSOAP2-Android Library - provides a lightweight and efficient SOAP client library for the Android platform.

The following game modes are currently supported:

- Singleplayer
- Singleplayer using web services
- Singleplayer using Flic buttons

4.4.2 Project Structure

- src
  - main
    - assets - the folder contains the official font of the app.
    - java
      - app - contains the constants of the application, base class for maintaining global application state and other configurations.
      - model - contains the database of the application, web services (data transfer objects) and classes for saving data.
      - presenter-view - comprises main logic of the application: implementation of basic activities, adapters, and some other helper classes: calling for SOAP services, particle effects, shared preferences, custom UI-components.
    - res
      - anim - some animation effects
      - drawable - contains files for the action of triggering buttons, all sprites, and textures used in the app
      - mipmap - the official icon of the application
      - raw - files the contain sounds
      - values - colours, strings and styles
    - AndroidManifest.xml - provides essential information about the app to the Android system, which the system must have before it can run any of the app's code.

4.4.3 Flic Integration

In this section, it will be described how is imported and configured the fliclib to the project in Android Studio.

- One need to create a new project or to open an existing one. The target of the project must be at least API 19 (Android 4.4)
- One need to open **File -> New -> Import Module...** and select the ***fliclib-android*** directory which can be checked out from *https://github.com/50ButtonsEach/fliclib-android*.

- One need to add a reference to the **fliclib** in the menu by clicking **File -> Project -> Structure -> app (in the left sidebar) -> Dependencies tab -> The button in the rightmost section -> Module dependency -> fliclib -> OK**.

All imported classes are in the package *io.flic.lib*. There are two significant classes [6]:

- ***Flick Manager*** – this is a singleton class used to communicate with the Flic Application. It keeps track of all the buttons and FlicButton represents a single button.
- ***FlicButton*** – this class represents a Flic button and instances of this class cannot be created directly but are returned from the manager. To fetch buttons, one needs to use the button grabber and to be able to receive button events in the background one need to register a **FlicBroadcastReceiver**.

Before the **FlicManager** is instantiated one need to set app credentials using the method **FlicManager.setAppCredentials**. This is done in the **Application** class. This class in Android is the base class within the application that contains all other components such as activities and services. The **Application** class, or any subclass of it, is instantiated before any other class when the procedure of the application/package is created. So the primary purpose of this class is the initialization of global state before the first Activity is displayed. The application ID and application Secret are particular for every application and can be created in the Flic developer portal. Now the user can exploit the manager that can be used to get a button from the Flic application, where the app will be opened up, and the user will be incited to choose one of his/her associated buttons. It will then send information about the button back to the application with the goal that the user can begin utilizing it. To get the button object, one must feed the result into the manager which at that point return it and with this object, one can register for notifications. Now the events will be sent to a broadcast receiver and in this way, the app will receive them even if the Android system has shut down the app process. One must create an intent name called **io.flic.FLICLIB_EVENT**, and declare it in

[6] https://partners.flic.io/partners/developers/documentation/android/index.html. Retrieved (2017, Jun 2)

the *AndroidMainfest* file. After that, the broadcast receiver should extend the **FlicBroadcastReciver** class, which posses a method called **onRequestAppCredentials**. Also, it is important to notice that since the application procedure may be started upon an event, the main activity is not started so it is not sufficient to give the application credentials there. For that reason, one must override the methods that will be called after getting the corresponding events.

4.4.4 Algorithm

The algorithm that is used in the application is developed by (Schön, Ebner, and Kothmeier, 2012) and the main intent of it is the selection of adequate questions as well as the classification of the given answers (the algorithm flow diagram is visualized in Fig. 4.5). Based on that two components are essential:

- Difficulty of the exercise – every learning activity posses difficulty ranks, and these ranks are described as values, which lie between 0 and 1. An easy question gets a high success probability value (close to 1) and a more difficult one gets a low success probability value (close to 0).
- Degree of competence – is computed (0 ... 1) to monitor the learning improvement of a user (learning rate), where the computation of this value relies upon the efficiency of each learner and is computed instantly.

Degree of competence

As (Schön, Ebner, and Kothmeier, 2012) emphasized, the degree of competence is one of the most important parameters of the algorithm, where the essential intention of that is to demonstrate which questions are "difficult" and which questions are "not difficult" with regard to user's knowledge. Degree of competence is a value which lies between 0 and 1, where the questions are constantly generated and selected according to their difficulty. When the algorithm requires generating a question, then this question should not be too difficult nor too easy. For the first time, it generates a random question. As illustrated in the Fig.4.6. the whole learning is separated into two subareas: learning area (known by the learner) and the extended learning are

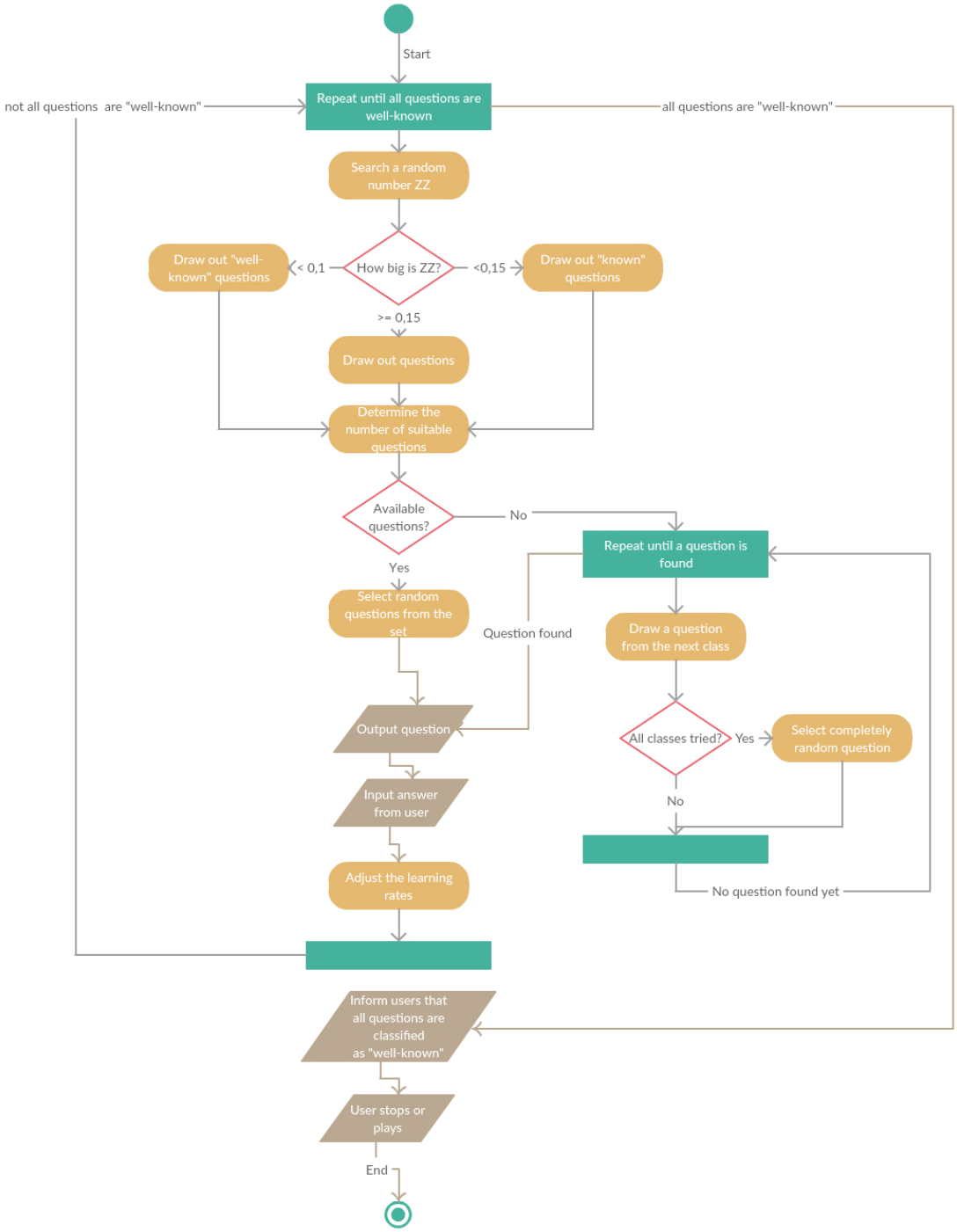

FIGURE 4.5: Algorithm flow diagram. (Schön, Ebner, and Kothmeier, 2012)

(unknown by the learner). In the extended learning area, the learners get the new questions and it is defined to be 25% above the learner's degree of competence. This parameter is relative and is based on the teacher's selection. That means if the learners provide a low degree of competence, then the teacher must keep down the extended degree of competence, and this will be increased in case of the success of learners.

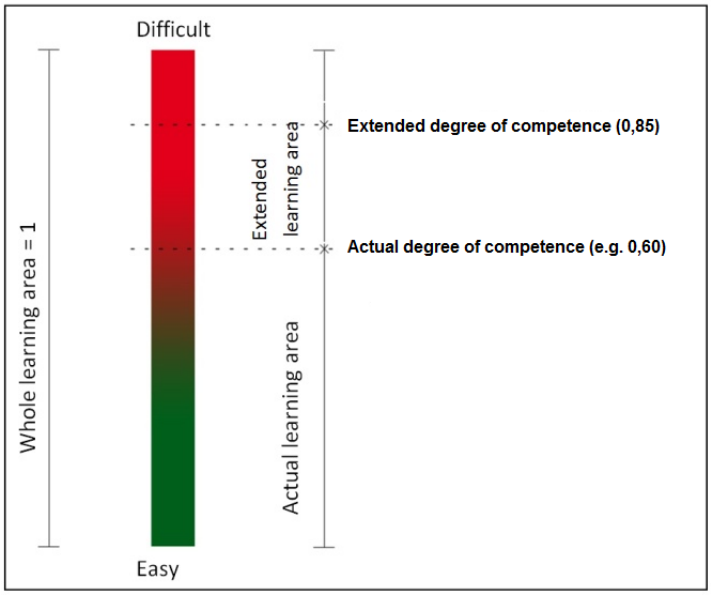

FIGURE 4.6: Visualization of the degree of competence (Schön, Ebner, and Kothmeier, 2012)

Pretest

Pretest as a process is used to estimate the learning aptitude of the users. Initially, it will be generated a moderate question, which lies between 0,54 and 0,47. If the answer is not correct then it will be generated an easy question, which lies between 0,20 and 0,13. Otherwise, it will be generated a hard question, which lies between 0,78 and 0,69.

In the next phase, it will be estimated the learning aptitude (DOC). If the hard question from initial phase is answered correctly, then the user will achieve the degree of competence up to 0,75. Otherwise, the user will achieve

0,50. If the easy question from the initial phase is answered correctly, then the user will achieve the degree of competence up to 0,25, otherwise 0,00.

The whole process of pretest is depicted in Fig. 4.7

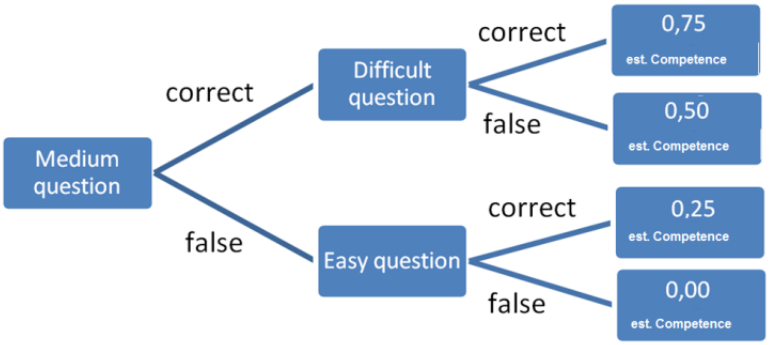

FIGURE 4.7: Visualization of the pretest (estimated degree of competence (Schön, Ebner, and Kothmeier, 2012)

Classification of answers

An important issue that the algorithm takes into consideration is the classification of well-known learning problems. Based on that the answers of the learners are marked with 0, 1 or 2.

- 0 – wrong answer
- 1 – the user knew the right answer once
- 2 – the user gave two correct answers in sequence (well-known). During this process, if the user failed into the next question, this parameter will be set back to 0.

Selection of questions

After the degree of competence is calculated using the formulae described by (Schön, Ebner, and Kothmeier, 2012) the next question should be selected. Based on that, there determined three categories, from which the questions are generated:

- Extended and Actual Learning Area (questions written with 0).
- Actual Learning Area (questions written with 1).
- Actual Learning Area (questions written with 2).

It is used a random number not in the interval [0,1] to decide which category is initiated. Based on that there are determined three conditions:

- Condition 1 – if the random number x <= 0,05 a well-known question (2) is selected.
- Condition 2 – if the random number is 0,05 > x >= 0,15 a known question (1) is selected.
- Condition 3 – if the random number is x > 0,15 an unknown question not in extended and actual learning area is selected.

According to these three conditions all questions are prepared pursuant to their difficulty and have corresponding ranks.

4.4.5 SOAP-Requests

SOAP (Simple Object Access Protocol) is an XML (Extensible Markup Language)-based messaging protocol and it characterizes a set of rules for organizing messages that can be used for basic one-way messaging but is especially helpful for performing RPC-style (Remote Procedure Call) request-response dialogues.

LoginService

login: as input data this method get the username and a password and returns the ID of the user.

QuestionService

getNewQuestion: this method get as input data the ID of the user and returns the ID of the new question, the label of the question and the answer of the question.

PretestService

checkPretest: as an input this method get the ID of the user and returns a boolean value: TRUE- the user has completed successfully the pretest, and FALSE-the user has failed to complete the pretest.

SessionService

createSession: this method requires as input data the ID of the user and ID of the Platform (Web app, Android or iOS). As a result, this method returns a session ID, by which all the questions will be generated and thus it is possible to create a more accurate statistical evaluation.

AnswerService

giveAnswer: as input data this method get the answer given by the user, the ID of the session, the time reaction and ID of the question and returns true/false whether the answer is stored or not.

4.4.6 Database and SharedPreferences

Android gives a few approaches to store client and application data. **SQLite** is one way for storing client data and it is a very lightweight database which comes with Android operating system. Another way to store the data is **SharedPreferences**, which provides a general framework that allows the user to save and retrieve persistent key-value pairs of primitive data types (booleans, floats, ints, longs, and strings). In the application there are created two basic tables in SQLite and also is used SharedPreferences class. The database basically contains two tables called PlayTable and TrainerTable. The first table is implemented in the Play mode (offline) and for every user, which finished a cycle of game it saves the userId (generated randomly), userName (given by the user), the correct answers, incorrect answers and total time taken to finish the game. It does not have any connection with PlaySharedPreferences, where this table is based in the context of the activity. That means everyone who plays the game on the phone/tablet and turns off the music, this state will be saved independently from the user. The second table is a bit different. It contains the userID, levelName, correct answers, incorrect answers and the level time. The preferences of the user are related to its id (generated from

the server) and based on that this table has a relation with TrainerSharedPreferences.

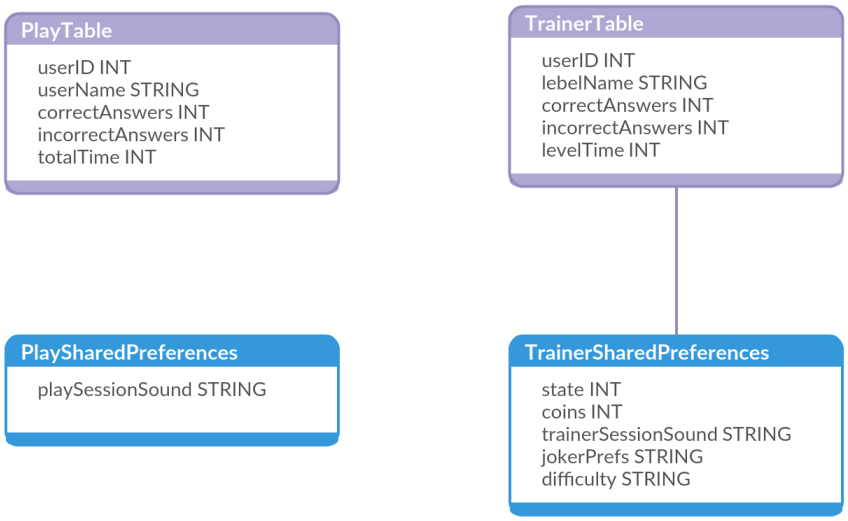

FIGURE 4.8: Database and SharedPreferences design

4.4.7 Particle Effects

As described in the "Development environment", it used an external library to support particle effects. There are some important aspects of this approach, in the way that how one can generate beautiful effects and this is illustrated in Fig.4.9:

- **Particle System** – it creates a particle system with the given parameters:
  - *maxParticles:* the maximum number of particles
  - *drawableRedId:* the drawable resource to use as particle (Bitmaps and Animations)
  - *timeToLive:* the time to live for the particles
- **setSpeedByComponentsRange** – loads the speed factors ranges that particles will be emitted. Speeds are estimated in density pixels per millisecond.

  - *speedMinX & speedMaxX:* – minimum/maximum speed in x direction
  - *speedMinY & speedMaxY:* – minimum/maximum speed in y direction

- **setAcceleration:** – instantiate the increasing speed for emitted particles with the given angle (measured in degress with 0 meaning to the right and orientation being clockwise), and this increasing speed (direction controlled by angle) is estimated in pixels per square millisecond.
  - *acceleration:* - increasing speed
  - *angle:* - the acceleration direction

- **setInitialRotationRange:** – instantiates the rotation range of emitted particles. The rotation angle is measured in degress: 0 -> no rotation and 90 -> tilt the image to the right.
  - *minAngle, maxAngle:* - the minimum/maximum tilt angle

FIGURE 4.9: Particle effects in game activity

Chapter 5

Evaluation[1]

In this chapter, the evaluation process of the prototype is described and thoroughly the drawing results. It is divided into two sections:

- The first section 5.1 describes the organization of the evaluation and its development process.
- The second section 5.2 demonstrates the results, difficulties, consequences, and conclusion of the prototype monitored in a secondary school.

5.1 Evaluation Arrangement

The project is successfully released in Google Play Store with the help of *Dipl.-Ing. BSc Markus Ebner* and it is installed in four smartphones where three of them were of type Motorola Moto E (2nd gen) and one Samsung Galaxy S6 Edge as shown in (Fig. 5.1.). All of these smartphones were equipped with Flic Buttons, where the same account of Flic [2] is used for all of them. Before the process of the evaluation, all the smartphones are tested by *Mag.rer.nat. Maria Haas* and everything went well. The evaluation took place on the 23rd of March 2018 in the "Neue Mittelschule (NMS) Fröbel" (secondary school) and lasted about one hour. The number of pupils that attended the evaluation was nine, where *Dipl.-Päd.Andrea Höhs* (the teacher

[1] Parts of this chapter have been published in:
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[2] https://wiki.winkathome.net/Flic_-_The_Wireless_Smart_Button. Retrieved (2017, April 26)

of the class) split them into two groups: the first group contained five pupils, whereas the second one contained four pupils. The pupils are invited in a separate room, where each of them is equipped with a smartphone and a proper Flic Button, except the first group in which two pupils used the same smartphone and the same Flic Button.

FIGURE 5.1: The picture shows a couple of smartphones that are used evaluate the prototype.

The process of the evaluation is conducted in three basic phases as follows:

1. **Introduction** –> Two groups of the pupils got explanations from *Mag.rer.nat. Maria Haas* about the game, on how they should use the buttons (three different functionalities), how many questions a game stage posses, where can they find the game in Google Play Store[3]. It is really important to note that every pupil understood very well every part of the explanation and they were interested to enjoy the game.

2. **Game Activity** –> After the given introduction of the game, the pupils started synchronously to play the game and they passed through twenty-five questions one after the other by giving their answers. Every pupil of the group did at least two cycles of the game and in the

[3]https://play.google.com/store/apps/details?id=com.hyperion.a1x1trainer&hl=en. Retrieved (2018, March 16)

end, they saved their results with different names in the database. Most of them used Flic Buttons to play the game but also some of them expressed the desire to use UI (User interface) buttons.

3. **Evaluation** –> There are determined five different statements for game evaluation. Regarding the statements, the pupils had to discuss in the group about the rating of the statements (not separately) and for that, there are provided different smileys as shown in Fig. 5.2. They had to cut smileys using scissors and to stick them in proper squares, based on the final decision that they made as a whole group.

FIGURE 5.2: The image shows the statements and the smileys that are used to estimate each statement.

5.2 Evaluation Results

After the explanation of statements and different modes of smileys (1,...,5) as showed above, the two groups gave their rating values and these values are demonstrated in Table. 5.1. In general children were happy that they were able to use a mobile application for learning mathematics especially multiplication table, that means in the same time trying to achieve positive results and on the other hand to enjoy playing. During the evaluation, it is

also worth noting that the majority of children realized more than 85% of all questions positively in the first round and when they repeated the game stage for the second time they improved more by giving even better results. All the time when they finished a game stage, they saved the results in a table (Database) and they compared new results with the previous one.

TABLE 5.1: The rating values from two different groups of pupils in the secondary school *NMS Fröbel* .

Statement	Group 1 - Rate	Group 2 - Rate
1. **The game was simple to use.** (Das Spiel war einfach bedienbar).	**3**	**1**
2. **The game was fun.** (Es hat mir Spaß gemacht zu spielen).	**4**	**3**
3. **I felt excited to solve the tasks using Flic buttons.** (Ich fand es cool die Aufgaben mit dem Flic button zu lösen).	**5**	**2**
4. **The tasks in the game were easy for me.** (Die Aufgaben im Spiel waren leicht fuer mich).	**1**	**4**
5. **I want to play the game again.** (Ich möchte das Spiel nochmal spielen).	**2**	**5**

The interpretation of the results obtained from Table. 5.1 is described as follows:

- **Statement 1 – >** One of the main important points of the game's design was the simplicity of material components. For that, there are used

good-looking game sprites to make it easier to understand. The pupils of the group one found it easy to use and also understandable, while the second group considered it more difficult. One of the reasons for that was the control of the Flic buttons, but over time this phenomenon improved considerably.

- **Statement 2 – >** The pupils considered the game really fun. Not only during their discussion in the group but also at the end of evaluation process they emphasized that the game was absolutely entertaining.

- **Statement 3 – >** It was really crucial during the development of the project to combine strictly factors as game and learning. The reason for that was to add motivation on the pupils to learn things easier and increase their engagement in the learning process. As a result, two groups found it really motivated and considered it significant to interconnect something completely external (Flic button) to the learning process.

- **Statement 4 – >** The generation of the questions was random including multiplication table from one to ten. Both groups expressed different opinions, where the first group seemed the generation of questions more difficult than the second one. Here is an important thing to note: when the question is displayed together with the wrong answer and this answer was really close to the correct one, then the pupils needed a little more time to analyze the question and to solve it.

- **Statement 5 – >** During the evaluation process the pupils honestly preferred to repeat the game several times and also to put the Flic button under the table in order to test the button from a larger distance etc. The second group rated with the maximal grade, whereas the first group surprisingly rated it a bit low.

Children were also interested in the role of Joker (Default Joker, as described in Chapter 4), where the main purpose of the joker was to give the right answer with the probability of 50%. They tried Joker Button for every question to see in the end how many outcomes were correct and wrong. Another phenomenon that has been observed is the speed that children performed in solving tasks. Based on all these aspects it is extracted a sample from two of the smartphone's database and as a result of it there are analyzed correct answers, incorrect answers, and time values of four pupils (two

boys and two girls) from different groups (Table. 5.2). For the privacy's sake, the names of the pupils are not revealed, so X1, X2 (Group one) and Y1, Y2 (Group two) are used instead.

TABLE 5.2: Statistics of four pupils in the secondary school *NMS Fröbel* .

Pupil	Correct Answers	Incorrect Answers	Time
X1 (first game stage)	23	2	58"
X1 (second game stage)	25	0	42"
X2 (first game stage)	24	1	79"
X2 (second game stage)	24	1	66"
Y1 (first game stage)	24	1	107"
Y1 (second game stage)	22	3	73"
Y2 (first game stage)	15	10	88"
Y2 (second game stage)	25	0	60"

From Table. 5.2, the mean average of the right answers is 22.75 (91%), where the mean average of time is roughly 72". This high score achieved by children clearly shows that it is really important for them to play educational games, to dive in the game environment for solving math problems, to use auxiliary game tools for moving on and in the end to check their progress for additional advancement.

Chapter 6

Discussion and Conclusion[1]

6.1 Discussion

The main objective of the thesis was to present a gaming prototype that facilitates the acquisition of the multiplication table. Therefore, as described in Chapter 4, it is implemented a game called 1x1 Trainer Flic. 1x1 Trainer Flic is an educative application dedicated to children, in which the player tries to learn the multiplication table by giving his answers.

The interface of the application is created in the simplest possible way to enjoy the learning phase and it is designed carefully to make the navigation for the children much easier. The main focus of the game is the seamless interactivity of the user with the game for learning multiplication. When running this application, the user should have fun and at the same time, the user could practice the multiplication property.

Furthermore, the application uses external bluetooth devices, which provide the interactivity between player and the game. For that reason, there are used some smart buttons called Flic[2].

Another thing worth mentioning is the analysis and combination of the key

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[2] https://wiki.winkathome.net/Flic_-_The_Wireless_Smart_Button. Retrieved (2017, April 26)

aspects obtained from different literature and their inclusion in the implementation of the application. Some of these aspects described by various authors are implemented in the application:

- a set of rules and constraints
- a set of dynamic responses to the learner's actions
- appropriate challenges enabling learners to experience a feeling of self-efficacy
- gradual, learning outcome-oriented increases in difficulty

6.2 Conclusion

Considering the substance of this thesis, it is clear that using mathematical computer games contributes to more efficient and quicker realisation of educational goals at all levels of education. The blend of implemented factors in the project (pupil enjoyment, pleasure, intense, then resulting outcomes, feedbacks, competition, challenge, problem-solving) has resulted in the motivation of the pupils to learn and increase their engagement in the learning process. Another significant aspect discussed in the thesis is the operation with external devices called Flic. From the evaluation of the application, it is considered that children were interested to use mobile devices together with Flic buttons for learning mathematics especially multiplication table. This means at the same time children tried to achieve positive results and on the other hand, they enjoyed playing. Using mobile-based games creates positive mental outlook to pupils toward mathematics, their dynamic participation is more noteworthy and the acquisition of mathematical knowledge, aptitudes is more efficient. In this way, these kinds of learning games should become an indispensable factor of modern teaching methods and their usage one of the objectives of modern training. In addition to this, from the obtained experimental results children were very enthusiastic about the new technological device (Flic), considering it very entertaining and at the same time as facilitation of the interaction with the game. They also claimed that they had never access to such devices ever before and they were amazed at how it could operate to enjoy the game. Even this device like many other new technological devices (depending on the user's viewpoint or the way

they approach) may have disadvantages. Initially, the price can be considered as one of the major barriers to the application of this technology. But, a variety of functions and applications (control lights, play music, track time, automate, present keynote, ping my phone) that Flic button posses, as well as the effectiveness shown in the 1x1 Trainer game, can be considered that it sufficiently justifies its existence.

Appendix A

Documentation

A.1 Naming Conventions

- Interface, Class, Abstract Class –> Game, TrainerMode, AbstractGameActivity
- Activity –> GameActivity, GameResultActivity, GameStatesActivity
- Adapter –> GameStatsAdapter, TrainerStatsAdapter
- Enum –> JokerEnum
- Method –> setGameResultImage(), setSoundEffect()
- Class/Local Variable –> fontStyle, gameBackButton, soundEffect
- Constant –> APP_ID, APP_SECRET

A.2 Classes

A.2.1 App

- EinMalEinsConstants - global constants which you can use everywhere in the project.
- EinMalEinsTrainerApplication - base class for maintaining global application state and other configurations. This class is instantiated before any other class when the process for the application/package is created. We need to make a communication with Flic App and this has to be done before the creation of other activities.

- FlicConfiguration - this class uses FlicManager Singleton to communicate with Flic Application.

A.2.2 Model

- Question - this class represents the question details
- UserStats - it implements Serializable, which it is used as an object to hold actual performance of the user, it is transmitted from one activity to another one and each row of the database contains this object.

Database

- GameDatabase - the database of the application which consists of two tables: the first one is used to save the data in the play mode and the second to save the data in the trainer mode. The table in the play mode consists of five rows: id, username, correct answers, incorrect answers and time while the table in the trainer mode is almost the same with only one difference level name in lieu of username.

Webservice

- AnswerDTO - a class that carry data between processes and communication between processes is done to remote interfaces (web-services), where each call is an expensive operation.
- SessionDTO - same purpose as AnswerDTO

A.2.3 View

- SplashScreenActivity - shows some kind of progress before the app loads completely.
- Game - is an interface which assigns some rules for both kinds of approaches Play and Trainer (they should implement them).
- GameWebService - a class which possesses static methods to call SOAP webservices.

- PlayMode - a class which implements Game interface and the basic idea of this class is to manage everything that has to do with question: generate a random question, evaluates the total time that user takes to solve it, returns the number of correct/incorrect answers etc.
- TrainerMode - is almost the same as PlayMode but it differs in that this class uses GameWebService functions to get the questions from the server, create a session, check a pretest etc.

Activities

- MainMenuActivity - class for UI management in the main menu.
- CreditsActivity - publicly acknowledge someone as a participant in the production of the app.
- AbstractGameActivity - as an abstract class it creates the basic functionality of the game, the interaction with the user and also it contains the broadcast receiver for events from the Flic App.
- GameActivity - class for UI management in a singleplayer, singleplayer using Flic buttons.
- GameResultActivity - class for performance display gained from the user.
- GameStatsActivity - class for maintenance of the statistics of the user (saving them in database and presenting them to the user).
- LoginRegisterActivity - class for UI management in the login screen.
- TrainerActivity - class for UI management in a singleplayer using webservices, singleplayer using webservices combined with Flic buttons.
- TrainerLevelsActivity - class for UI management in the levels screen.
- TrainerLevelsResActivity - class for performance display gained from the user.
- TrainerLevelsSettingsActivity - class for UI management in the settings screen.

- TrainerLevelsShopActivity - class for UI management in the shop screen (selection of the jokers).
- TrainerLevelsStatsActivity - class for maintenance of the statistics of the user (saving them in database and presenting them to the user).

Adapters

- GameStatsAdapter - adapter which is used to present data in a structured manner.
- TrainerStatsAdapter - the same purpose as GameStatsAdapter.

Enums

- JokerEnum - enum with jokers types (default, star, bomb & heart).

Utils

- GameDialog - a custom dialog that prompts the user to a decision or gives additional information.
- GamePreferences - a general class that allows other classes to save and retrieve persistent key-value pairs of primitive data types.
- ParticleEffect - a general class which is responsible for creating particle effects.

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