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Exploring girls' perception on Computing careers via educational quiz-application

Kshitiz Adhikari

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Supervisor: Letizia Jaccheri, IDI
Co-supervisors: Kshitij Sharma, IDI and Javier Gomez Escribano, IDI

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Abstract

Background: Being one of the fields with highest prospect for development and opportunities, it is now time for females to grab these opportunities in Computing. In order to accomplish, the first priority is to increase females' interest towards Computer Science from young age. While researchers have made attempts to assess and increase young females' interest in Computing, they have failed to address the prospects of careers in Computing and why females should be interested in them. There is a lot of potential to influence preteen females' choice of career through interactive technologies.

Objective: This thesis explores the impact of an educational quiz application on its users' perception towards Computing careers. The research aims to exhibit relevant research studies performed to address this research problem, and reveal results and discussion on the topic of educational applications and serious games. Additionally, the research focuses on designing and developing an application which aspires to increase preteen females' interest in Computing careers.

Method: The research method employed is design and creation where the developed artefact (the quiz application) is the produced outcome of the method. Additionally, to evaluate the application, an experimental research method has been implemented with the assistance of 76 participants.

Result: The result includes the background of the research and the evaluation of the quiz application. The participants, professionals in the field of Computer Science, displayed positive attitude towards the quiz application and indicated the possibility in increasing preteen girls' interest in Computing careers.

Limitation: The application, developed as a proof-of-concept, is in its early development to strongly appeal to preteen girls. Subsequent changes in the application must be made and evaluated. Inability to evaluate the application with the focus group (preteen girls) gives rise to an unpredictable outcome in the future.

Conclusion: The outcome of the research reveals opportunities for using educational applications and/or serious games to teach Computer Science concepts and eventually, increase female participation in Computing industry.

Preface

This thesis report is submitted to the Department of Computer Science at Norwegian University of Science and Technology (NTNU) as part of the course TDT4900, Master's Thesis.

The work has been done under the supervision of Professor Letizia Jaccheri as the main supervisor and Post Doctoral Fellows Kshitij Sharma and Javier Gomez Escribano as co-supervisors.

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Abbreviations

CS	=	Computer Science
CS4FN	=	Computer Science for Fun
EiT	=	Experts in Team
ENIAC	=	Electronic Numerical Integrator And Computer
GDPR	=	General Data Protection Regulation
HTML	=	Hypertext Markup Language
IT	=	Information Technology
MIT	=	Massachusetts Institute of Technology
NCES	=	National Centre for Educational Statistics
NCWIT	=	National Centre for Women and Information Technology
NSD	=	Norwegian Centre for Research Data
RQ	=	Research Question
STEM	=	Science, Technology, Engineering, and Mathematics
SUS	=	System Usability Scale
UNESCO	=	United Nations Educational, Scientific and Cultural Organization
USA	=	United States of America
USD	=	United States Dollar
WITI	=	Women in Technology International
WTP	=	Women's Technology Program

Chapter 1

Introduction

The underrepresentation of women in Computer Science is a known issue to all. Girls' involvement in Computer Science has seen a drastic change throughout the years. Computer Science is mostly known as a male-dominated field surrounded by negative stigmas such as boring and tedious. In the USA alone, women accounted to 37% of Computer Science graduates in 1985 while the number went down to 17.6% in 2011, according to National Centre for Education Statistics (NCES (2012)). In last 15 years, women in Computer Science has dropped drastically from 35% to 25% (NCES (2012)). This surge is said to be an effect of the "Seismic Shift" which occurred in the 1980s when personal computer gained popularity and the field of Computer Science became mainstream which changed people's perception and thus, Computer Science became an industry for men (Williams (2017)). Jane Chappell (Raytheon (2018)), Vice President of Global Intelligence Solutions, describes the male domination in Computer Science as it became viewed alongside math, science and engineering, which were all male-dominated fields (Williams (2017)). Abundance in involvement of women in the field of Computer Science, such as programming and software engineering, is a trending topic today, but it has not been long since this started. Williams (2017) suggests that Computer Science/Information Technology consistently stands out as one of the best employment fields, specially for women. According to the Bureau of Labor Statistics, USA, only 21% of women are computer programmers, 19% are software developers, and 32% are web developers (Labor Statistics (2019)). Generation STEM Research Study states that while 74% high school girls are interested in STEM related fields, only 25% career positions are held by women (Scouts (2012)). This thesis aims to increase preteen girls' interest in Computer Science via multimedia-embedded application.

The introduction consists of six subsections. In Section 1.1, we will learn about

the motivation of this thesis project. This is followed by the project description and project context in Sections 1.2 and 1.3 respectively. Then we shall discuss the objective of this thesis in Section 1.4. Section 1.5 describes the research methodology chosen for this study. The outline of the thesis report is stated in Section 1.6.

1.1 Motivation

In the past decade, Computer Science careers has seen tremendous rise in demand all over the world. Additionally, the pay scale has also risen making it one of the most sought out career option. With the increase in technology integration in people's lives, Computer Science has become an integral part of their lives irregardless of their awareness on this. The fields in Computer Science is growing day-by-day, which first started with Web Development and Software Engineering has now evolved to Artificial Intelligence, Machine Learning, Big Data, and so on. The industry is growing beyond its limit with an ambition to recruit more professionals to achieve even more.

Groover (2009) states that women's interest in the field of Computer Science has declined over the years. This field is still known to many as male-dominant industry, and this is still true as most Computer Science environments are occupied predominantly by males. Studies to address this issue began as early as the 2000s. Additionally, those studies focused on increasing interest of women in Computer Science as a viable career option. Miliszewska and Moore (2010) presents various strategies developed and used in order to increase the interest of women in Computer Science careers. These strategies focus on exposing young girls to Computer Science since an early age with the ambition to get them attracted towards the domain. One such strategy was the introduction of Computer Science via web-based applications/platforms. Web-based applications such as Hopscotch [1] and ScratchJr [2] introduces girls to computer programming and enables them to design their own games or stories (Cary-Alvarez (2016)).

The ambition to get young girls acquainted with Computer Science yielded applications such as Alice [3], Scratch [4], Move the Turtle [5], and KIBO [6] to name a few (Slavin (2014)). These applications aimed to teach diverse concepts ranging from basic computer science concepts to robotics. These applications also focus on developing young kids' capability to analyze programming problems before deriving

[1] https://www.gethopscotch.com/
[2] http://www.scratchjr.org/about/info
[3] http://www.alice.org/
[4] https://scratch.mit.edu/
[5] http://movetheturtle.com/
[6] http://kinderlabrobotics.com/kibo/

a solution. For example, Adams (2010) stated that kids in their study used Alice 2.0 to create computer-generated movies, and, in process, learned about object-based programming. Applications like this do not have a closed boundary, as opposed to games which have certain tasks and levels, which enables the kids to show their creativity without any limitation. Many multinational companies aimed to profit from this increase in interest towards Computer Science/Information Technology industry while encouraging children to explore the technology to achieve computing experiences for technologically advanced future.

Applications like Scratch gained popularity among both children and adults with their seemingly easy method for teaching. Additionally, these applications focus on teaching without making the whole learning process more complex. Hence, learners are taught programming without actually writing a single line of code. Claire Pritchard, a K-8 Tech Integration Specialist in Chicago, uses Scratch and ScratchJr to teach computer science/programming concepts to her students (Nguyen (2016)). Pritchard explains that, with the use of Scratch and ScratchJr, her students can understand basic logic concepts, write clean code, and complete these things using only graphical interface. Use of such applications helped students with developing a programming mindset while doing things step-by-step (Otts (2016)).

In more recent studies, workshops have been conducted to teach students basic Computer Science concepts via technologies such as Scratch (Adams (2010)). This thesis aims to access children's perception on Computer Science careers through a go-through session of an application specially built for preteen girls. We aim to identify the results and impact along with limitations, and suggest potential improvement on the current work.

1.2 Project Description

This master thesis showcases a design research process based on a media-integrated quiz application and its effects on preteen girls' perception on Computer Science careers. The application developed for this project aims to grab an understanding on the change of preteen girls' perception on Computer Science careers after the gameplay session. The research question that this thesis aims to answer is to determine a relation, if exists, between such educational gameplay session and preteen girls' perception on Computer Science careers. The idea implemented in the application consists of a quiz integrated with videos where the players have to answer the questions based on the video. The application also targets to teach a few basic Computer Science concepts to the participants. The aim of this project is to gather further developmental possibilities in the application to broaden the

concept in future. The application is also a part of the Tappetina [7] ecosystem.

The application makes use of digital system to expose the audience to female Computer Scientists and their groundbreaking work, and different Computer Science concepts. Due to the preliminary form of the application, this project mainly exists as a proof-of-concept. The application tries to implement a few Gamification elements to provide the gaming experience to the players. The application makes an effort to provide knowledge of female Computer Scientists and their career because the audience of the project are mainly female, and attempts to teach basic Computer Science concepts used in programming. As selection of subjects and data collection are integral part of this research in order to improve the concept and the application, exploratory research approach is implemented in the study to further develop the prototype. A predefined future work on this project could be to implement more gamification elements and modify this application to a game with more interaction between players.

1.3 Project Context

This thesis project is conducted as part of a larger ecosystem, Tappetina. This ecosystem was formed under the novel "The Little Doormaid: Tappetina" (Jaccheri (2017)). The application developed for this thesis project is also a part of the Tappetina ecosystem and follows the direction of the ecosystem to encourage the enrollment of more young girls in Computer Science domain. The author of the novel is Letizia Jaccheri, who is also the supervisor of this thesis project. The idea for this thesis began during the Experts in Team (EiT) course in Spring 2018. A group of students, along with the author of this thesis, worked together to create an animated video which showcases the story of Tappetina briefly. The video exhibited Tappetina's interest in Computer Science and Innovation. The main motive of the video was to see whether the integration of media in learning could inspire learners. A post survey conducted by the students showed that media tools such as animation could produce remarkable results in terms of learners and their achievements. Additionally, Tappetina ecosystem's ambition is to increase girls' interest in technology and its related fields, all while trying to combat stereotypes present in this field. The ecosystem is also responsible for workshops run for kids to teach IT and programming. This project, also being part of the Tappetina Ecosystem, endorses Tappetina as the face of the project and focuses on female Computer Scientists in order to address that gender.

[7] www.tappetina.com

1.4 Research Questions

The main objectives of this thesis are to explore the available research on encouraging preteen girls towards Computer Science careers and observe necessary inspiration to develop the application. Additionally, the aim is also to develop an application that enables preteen girls to learn programming concepts multimedia integrated in the application. The objective is also to determine to what extent does the application makes an impact on learner's perception of Computer Science careers. Hence, the research questions will be:

1. RQ1: What impact can educational applications have on girls perception of Computer Science?

2. RQ2: How can a educational application make an impact on preteen girls' interest in Computer Science careers?

1.5 Research Methodology

The first research question (RQ1) builds the background of this thesis. RQ1 represents previous research and works done in order to combat this research problem. The literature review thus devised is documented in Chapter 2 in this thesis. The second research question (RQ2) implies the decision to develop the application with the ambition to access and increase preteen girls' perception of Computer Science careers. In order to answer RQ2, the research strategy uses design and creation procedure, as discussed by Oates (2006), used to develop the application. Additionally, exploratory research approach is used to determine the best data collection methods and research design process (Oates (2006) and Burns et al. (2016)). The application is developed, tested and analyzed by the developer, and user testing is also performed. Detailed description of the research strategy is presented in Chapter 4 in the thesis. Surveys and interviews are the main source of data collection. The result of this research shows how applications with educational content can be designed and factors necessary for making learning fun and positively impacting young minds. The results also provide insights to gamification in order to make applications with learning content more interesting and appealing to the target audience.

1.6 Thesis Outline

The thesis report proceeds as discussed in this section. In Chapter 2, the background of the study and related work is introduced. This section explains the

contributions of educational applications used to encourage students (specially, preteen girls) to study and pursue Computer Science. Chapter 3 provides a timeline showing the processes in design and development of the application. This includes conceptualization, prototyping, and actual development of the application. This chapter also showcases the developed application and its functionalities and how the application progresses. Chapter 4 contains detailed information on how the application was evaluated and also, outlines the outcome of the project. This is followed by Chapter 5, which discusses the project, its contribution in the research, and potential work in the future. Finally, Chapter 6 concludes this thesis report with a brief summary on the achievement of the research objective of this thesis.

Chapter 2

Background

2.1 Women and Computer Science

Computer Science has become one of the most pursued career domain in the last decade with its ability to integrate with diverse field of sciences like natural science, social science, engineering, arts, humanities, business, law and medicine. The course of the definition of Computer Science has also changed from design and use of computers to various theoretical and practical disciplines such as Software Engineering, Data Structure and Algorithms, Programming Language Theory, Computer Architecture Engineering, and Human-Computer Interaction. These disciplines can also be further sub-divided into smaller disciplines. When Computer Science was introduced as a domain in the field of academia (in the 1950s and 1960s), this discipline was at a rather developmental stage (Tedre (2014)).

The introduction of the Internet and the Information Age is responsible in development of Computer Science from an emerging field of study to a massive industry it is today (Constable (2000)). In simple terms, computer science and internet changed the face of the earth and made humans' life easier. Internet made information sharing and communication easier and faster, regardless of the distance. This transition from manual work to computerized way is also termed as the Digital Revolution. The digital revolution also integrate Computer Science to every electronic device ranging from household appliances to space technologies. Additionally, every sector that involved humans, such as home, offices, education, started using Computer Science, computers in general. This rise in the use of computers triggered an equal rise in the demand of Computer Science professionals who could operate the computers.

It is known to all that, in general, women are underrepresented in Science. According to UNESCO Institute for Statistics (Institute for Statistics (2018)), fe-

male contribute to only 28.8% of the world's researchers. Bailie (2015) has successfully documented the struggles faced by women in Computer Science since "The Women of ENIAC" to women today. Studies shows that during their young years, women are equally interested in Mathematics and Computer Science as men. However, Martincic and Bhatnagar (2012) informs that, after college, women quit Computer Science in a rate twice as men do. Computer Science has been a male-dominated field not only in the past, but even today, the industry consists of mainly men. Additionally, Computer Science field is full of negative stereotypes. One such negative stereotypes as documented by Miliszewska and Moore (2010) states Computer Science professionals as anti-social individuals who do not possess a good personality and lacks diversity in interests. Cheryan et al. (2009) and Fisher and Margolis (2002) discloses additional terms such as 'geeks', 'nerds' and 'hackers' used to describe a Computer Science professional. Negative stereotypes make powerful impact on the behavior of the individuals and another such stereotypes is "Sitting in front of Computer screen all day long". The results of Carbonaro et al. (2010) presents the negative impact made by such stereotypic comments on the students when few participants reported their lack of interest in Computer Science career was a result of their lack of desire to sit in front of a computer screen all day. Another stereotypic comment that has been predominant in Computer Science since the beginning of this industry is "Women cannot do Computer Science". This is an example of demoralization of females towards Computer Science. This demoralization is document in Black et al. (2011) where female participants rated their abilities lower than men's even though their grades were higher. Even though negative stereotypes persists in Computer Science, organizations such as Anita Borg Institute [1], the National Center for Women and Information Technology (NCWIT) [2] and Women in Technology International (WITI) [3] supports and encourages women towards computer related fields. These organizations also base their works to increase female participation in Computer Science by reducing negative stereotypes. An study conducted at The Uppsala University in Sweden (Couderc et al. (2015)) reports that women associated Computer Science domain with intelligence and hard work, and had fewer negative stereotypes towards the domain as compared to men.

As stated by Palma (2001), young men are more interested and attracted towards Computer Science as compared to women because of their interest in gadgets and innovation, and in building things. Palma (2001) also reported that Bill Gates and Paul Allen's basic interpreter and Steve Wozniak and Jobs' first machine were a product of challenge and were build to amaze their colleagues in the Silicon

[1] https://anitab.org/
[2] https://www.ncwit.org/
[3] https://www.witi.com/

Valley. Women are becoming more interested in Mathematics and Palma (2001) suggests that integrating teaching concepts of Mathematics into Computer Science could be able to attract women towards Computer Science. Women should be an integral part of computing domain for various reasons, and Bailie (2015) described one of the reasons as the ability to produce different perspectives and strategies in order to acquire knowledge and solve problems. Rhee and Kim (2012) explained the existence of gender differences in acquiring analytical thinking and problem solving capabilities. Rhee and Kim (2012) also reports that women were more fascinated in career related activities than men.

2.1.1 Women in Computer Science careers

Studies suggest that low participation of women in Computer Science is not a problem only in the industry but starts before getting into the job industry. According to the statistics provided by ComputerScience.org (2017), boys outnumber girls in the ratio 4:1 in Computer Science placement exams. In the USA, in the year 2014, not a single girl participated in the Advanced Placement Computer Science examination in three states (Mississippi, Montana and Wyoming) (ComputerScience.org (2017)). Fisher and Margolis (2002) and Cundiff et al. (2013) suggests that negative stereotypes such as "Computer Science is inappropriate for females" is responsible for low confidence of women and their sense of belonging in the field. These negative stereotypes can affect the choice of future career alternatives for females. Rommes et al. (2007) reports that statements suggesting Computer Scientists' to be asocial conflicts with women's desire to have a balanced professional and social orientation. Women value working together with people (Ramírez et al. (2016)) as compared to men who do not share similar interest in people (Su et al. (2009)). Female professionals in the field of Computer Science has certainly decreased as compared to the numbers in the 1980s, but women in high technology positions has definitely escalated as compared to the statistics from the 1980s (Thuraisingham (2015)). Brown (2014) shows a different aspect which covers why women lack interest in Computer Science. Brown (2014) talks about a study conducted in the University of California, Berkeley, with the ambition to close gender gap in Computer Science subjects. The study informs that the approach in which the Computer Science courses are marketed might not be suitable to attract female students. In 2014, change was made to the name of the course from "Introduction to Symbolic Programming" to "The Beauty and the Joy of Computing" which resulted in women outnumbering men in the class for the first time.

The industry of Computing is occupied with endless opportunities, and both men and women can equally be part of this evolution involving rapid innovations and developments by developing cutting-edge technology (Thuraisingham

(2015)). Lockard and Wolf (2012) reveals Computer Science careers to be more profitable in terms of knowledge, experience and pay. Additionally, Computer-Science.org (2017) reveals that gender pay gap is very low or even non-existent as compared to other professions and industries. Various initiatives are taken by tech giants like Apple and Google to reduce gender disparity in technology. Both, Apple and Google, have taken measures to encourage women to explore Computer Science and gain success with the learnt skills (Miller and Webb (2015)). These initiatives from renowned technology giants can create ripple effects in the industry which in turn can inspire women to explore Computer Science careers. In the USA, the fastest growing occupation is Software Engineering with an annual growth rate of 32.4% and has a generous pay rate of more than 100 thousand USD annually Lockard and Wolf (2012). The demand of professionals is on the rise, and future projection shows that professionals in Computer Science and Mathematics has a projected growth of 22% from 2010 to 2020. To meet the demand of the industry, women have to be more involved in this domain. Seron et al. (2016) describes that women want to work in fields that contributes to the society. In their studies, Mota and Adamatti (2015) and Robinson et al. (2015), reported that participants perceived Computer Science as a communication media which is capable of making an impact on their daily lives. The result from Seron et al. (2016), Mota and Adamatti (2015) and Robinson et al. (2015) correlates with women's desire to help the society which is a motivational factor towards a Computer Science career.

Many research studies have been conducted to determine factors that can help increase the number of females in Computer Science. Tillberg and Cohoon (2005) is one such study, and states four main factors, namely, supporting and motivating parents, encouraging teachers, exposure to Computer Science at school, and playing computer games, that influences girls to study Computer Science. Fisher et al. (1997) highlighted that influence of family is a crucial factor on girls' interest in Computer Science and its studies. Accordingly, they also pointed out that while parents' and teachers' encouragement was stated as one of the most important reason for females' attachment with Computer Science, these factors were not as highly rated as girls' interest, class activities and experiences, and future possibilities in the field. A number of programs across the globe work together with an objective to expose young girls to Computer Science with the ambition to get them interested in Computing careers. Some of these programs are Girls Who Code [4], SciGirls [5], Girls, Inc. [6], and Girlstart [7]. In addition to exposing girls to Computing domain, these programs also promote gender parity in technology.

[4] https://girlswhocode.com/
[5] https://pbskids.org/scigirls/home
[6] https://girlsinc.org/
[7] https://girlstart.org/

Several studies have been performed in order to identify effective ways to expose girls to Computer Science and strengthen their interest in Computing careers in future. Klawe (2015) informs readers of such an study, conducted in the Harvey Mudd College in 2015, where the curriculum of their programming course was re-designed by making it more creative-problem solving and less pure programming. The administration also provided opportunities related to the course in the industry. In the next four years, the number of women who took the course went up by 30%. One other problem researchers have faced in this field of study is the lack of female role models which makes it difficult for young girls to relate themselves to if they study Computer Science. Black et al. (2011) tried to combat this problem by issuing a booklet, available online for free, which contains female role models and their groundbreaking work in the field of Computer Science. This study was a part of the project called Computer Science for Fun (CS4FN [8]). The booklet, that is published twice a year, also had information related to current trends and technologies in the industry. Likewise, another study (Bailie (2015)) contains a website [9] full of historical women in Computer Science. The website provides information from the times of Ada Lovelace, a mathematician who programmed Charles Babbage's Analytical Engine in 1843, to Yoky Matsuoka, the Vice President in a company that focuses on developing technology that enables people to conserve energy.

2.2 Strategies to increase girls' interest in Computer Science

According to an study conducted by Google (2014) to access major factors that affects women's decision towards a Computer Science degree, four primary indicators were determined which are listed below:

- Social Encouragement: Positive response and motivation from closed ones on persuasion of Computer Science.
- Self Perception: Confidence in one-self that critical thinking and problem solving skills can suffice in providing a successful career.
- Academic Exposure: The opportunities to participate in curriculum and/or extra-curricular Computer Science courses/activities.
- Career Perception: Positive thinking towards Computer Science as a career with societal impact.

[8] http://www.cs4fn.org/
[9] https://sites.google.com/site/womenincomputingbailie/

One way to get more women in Computer Science is by focusing on aforementioned factors in the society. However, only a single factor is rather unlikely to yield results as the absence of other motivating factors could fail to boost the confidence towards Computer Science as a career. Therefore, when applying more stress into these factors, one should consider an amalgamation of multiple factors. An example of strategy to include more women in Computer Science includes MIT's Women's Technology Program [10] (WTP) which started in 2002 with the goal to increase high school girls' interest to study engineering and Computer Science in future. The program runs a rigorous 4-week summer workshop where high school female students with hands-on and team-based activities. Programs as such, and moreover, summer camps are popular among young children. There programs can be used to access their understanding and knowledge in certain topic and help them to learn new skills and interest in short duration of time. Urness and Manley (2013) conducted an study which involved the organization of a summer camp for a week where female participants were underrepresented (only 17% of total participants). Urness and Manley (2013) then concluded that camps focused only to females would be more friendly, engaging and appealing to them. In another study conducted as part of participants' curriculum (Sweedyk (2011)), the researchers integrated a game design project into students' course to evaluate their interest in the topic and how it would impact their Computing choices in future. In 2010, the next barbie to be launched was announced (by Matte, Inc.) to be a computer engineer, as this profession got the most votes from the public, even though most young girls voted for the profession news anchorwoman (Cheryan et al. (2015)). Additionally, Martincic and Bhatnagar (2012) surveyed women's attitudes towards the Computer Engineer Barbie. 75% of the participants agreed that the doll could influence a girl's decision to enter the field of Computer Science.

2.3 Educational Applications

As the terminology suggests, educational application can be defined as a computer software with the primary purpose of educational purpose used in order to make education more efficient and effective. Jayne Clare, the co-founder of Teachers With Apps, had defined a holistic approach to define an educational application (Clare (2013)). Clare (2013) defines an educational application as an application that is user-friendly, aligns quiet well with the target audience, caters to the objective the application aims to achieve, and is appropriate to the target age-group. The history of educational application dates back to the 1930s when Edin Albert Link designed and built the world's first flight simulator, known as The Link Trainer, aka

[10] `http://wtp.mit.edu/`

Blue Box or Pilot Trainer (McFadden (2018)). The flight simulators used analog computers to generate simulated data. With early attempts like these in the World War II era, educational softwares came into existence. After the introduction of the personal computer, the revolution in computers began. Since then, we have come a long way from mainframe computers, owned by governments or universities, to cheap, easily accessible computer devices like laptops, phones and tablets. This revolution in computers has reshaped educational softwares or applications.

Growing popularity of technology among children is stated in an article (Dividend (2018)) which reports that 56% of preteen kids, aged 8 to 12, have a mobile phone. Additionally, 58% teens have access to a computer, almost 91% of teenagers are online via mobile device, and more than 50% parents stated that schools should make more use of mobile applications for education. Also, 86% students felt that the use of technology made learning more effective and efficient to them. Lastly, around 68% parents agree that mobile devices can be for learning. Technology's easy access made it more popular among children, since, students can find and capture required information in seconds. They can download applications from an online library to learn whatever they want, thus, making education the third most popular category of applications in the Apple's application store. Likewise, this growth in followers of online learning has led the mobile-learning market to exceed an evaluation of 37 billion USD by 2020.

An ideal educational application, according to Clare (2013), should encompass high quality, user-friendliness from the beginning of the application, contain activities that complement the content of the application, and should be connected with a learning objective. The learning objective can be as part of the child's curriculum, or can also be independent exercises. Clare (2013) also points out some advantages of educational applications in learning such as engagement, a feeling of ownership, inspires learning, and puts forward various solutions for the same problem. Early research findings shows that children younger than 2 years of age can learn through playing mobile devices (LLC (2011)). Another study performed in Australia, New Zealand, USA and Britain reveals that children aged 2 to 5 years old are able to manipulate mobile application rather than ride bikes or tie their shoelaces (Grose (2013)). Goodwin (2012) states that educational applications can create exciting and effective learning environment for children from very early childhood. Hirsh-Pasek et al. (2015) suggests that children learn the most when the learning experiences are meaningful and interactive, when they are actively engaged, and when learning has a specific goal. The effectiveness of educational applications are also supported by LLC (2011), which states that children can progress swiftly from novice to master through a well-designed educational application.

An educational application is evaluated with its ability to support learning

alongside the user's undistracted engagement via which the learning goals are achieved. Hirsh-Pasek et al. (2015) states that while sound effects and animations might be appealing factors to the user, they can also be regarded as a factor that decreases the user's understanding of the actual content through disruptions in learning coherency and engagement. Hirsh-Pasek et al. (2015) discusses three elements of application design that can provide strong engagement in learning. The first design element is "Contingent Interactions", meaning immediate response to an action such as an action taken after touching a button. Contingent interactions provide a feeling of control when using the application which maintains their focus, thus, continued interaction with the application. The second design element is "Extrinsic Motivation and Feedback" which deals with a meaningful feedback from the application to the user's activities. This feedback can be actions such as labels showing "Correct!" or "Incorrect!", motivational messages like "Great Work!" or "Better luck next time!" or "Try Again!", and social displays like animated crowd cheering, which provides meaningful content when the application progresses. Through this, applications can actively focus user's attention in the learning goal and extend their engagement with the application. Lastly, the third design element is "Intrinsic Motivation" which contains a more open-ended design where the user can innovate. An example for this is *Morton Subotnicks Pitch Painter*, this application enables children to create and play musical notes which might enliven the children's interest in creating or playing music (Hirsh-Pasek et al. (2015)). These experiences can be very engaging, since it is known that any person can lose track of time when engaged in an activity of their interest (Csikszentmihalyi (1991)). The effectiveness of these design characteristics are discussed in detail by Mayer (2014).

2.3.1 Educational Applications over the years

Since the beginning of the internet age, computers have become common in education. However, it has not been long since the use of computers and software were incorporated in learning with kids. Today, such educational softwares have multiplied in an exponential order, thus, there are applications that appeal to children of any age group and demographic. In this section, we will try to discuss some applications with possible Computer Science learning goal.

Tynker [11] is an educational platform which promotes kids to become innovators with the aim to teach them to develop games and learn programming. It is a block-based platform where kids use various blocks to create desired functionality, similar to **Scratch** [12] . This is a commercial platform which is accessible from

[11] `https://www.tynker.com/`
[12] `https://scratch.mit.edu/`

both, mobile and tablet. **CS Unplugged** [13] is a collection of various learning activities with an ambition to teach Computer Science to children through games and puzzles. CS unplugged is more like a project, than an application, which makes use of both traditional and digital settings to teach Computer Science. **Code.org** [14] is a non-profit organization with an objective to increase access of Computer Science in schools and also increase overall women's and minorities' participation. Code.org prioritizes Computer Science above all other sciences with their vision "Every student in every school has the opportunity to learn Computer Science". **Kodeable** [15] is a platform where children can learn to think like a programmer to writing real JavaScript programs. Some other educational applications that are used to increase children's interest in Computer Science are **beanz**, **CodeMonkey**, **Lightbot**, **Alice**, **AgentSheets**, **RoboMind**, and **ToonTalk**.

2.4 Serious Games

Serious games are games that are designed and developed to serve educationally rather than pure entertainment. Laamarti et al. (2014) reveals that the serious games' industry has seen a tremendous rise from its initial point in 1995. Serious games was first introduced by Abt (1970) in the book "Serious Games" published originally in 1970. This book states the concern for the games' educational purpose and not to be played primarily for amusement. An overview of the evolution of serious games' research over the years is provided by Laamarti et al. (2014), and can be seen in Figure 2.1.

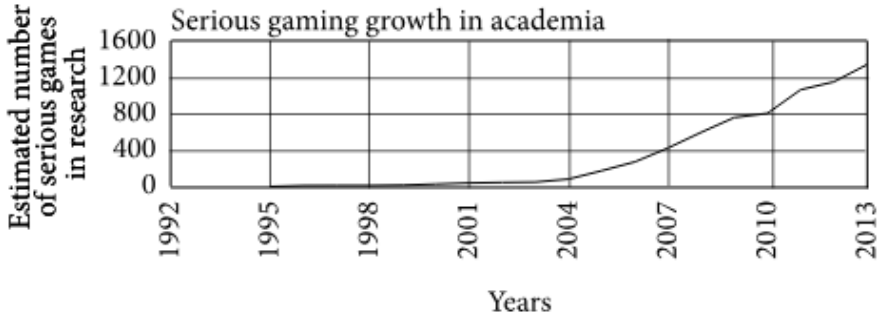

Figure 2.1: Laamarti et al. (2014): Growth of serious games research within the years

[13] https://csunplugged.org/en/
[14] https://code.org/
[15] https://www.kodable.com/

Prior to serious games, games were described by six main characteristics (Michael and Chen (2005)): Voluntary - a form of freedom, Pretend (non-realistic), Immersive, Limited, Social, and Rule-based. These characteristics lacked fun, and according to a survey conducted by Michael and Chen (2005), 80% participants said that fun is important in a serious game. Serious games often disobey the "Volunteer" characteristic since players are put under a limitation to play a certain game. Much research has been done to incorporate the element of fun into serious games. Esper et al. (2013) stated that many educational games are criticized and called "Chocolate flavored Broccoli" because the educational component of the game interrupts smooth gameplay. Furthermore, Laamarti et al. (2014) stated the link between games and military when the introduction of Odyssey by Magnavox (launched in the USA in 1972) which is considered the first serious video game because of its potential as an educational tool. As of 2012, Laamarti et al. (2014) estimated the number of serious games in the industry to be 400. Though this number is not huge as compared to normal games (consoles and PC), the growth of serious games has increased exponentially. According to Sonawane (2017), the global serious games market was valued at 2.731 million USD in 2016 and is projected to reach a value of 9.167 million USD by 2017 to 2023.

Michael and Chen (2005) stated that Ben Sawyer, the co-founder of Serious Games Initiative, defined the 'serious' in serious games as the purpose of the game and the reason for its creation. The idea of a serious game does not have to be necessarily a computer game. Using traditional board games for with the purpose of educating the players on a certain subject matter could suffice to be recognized as a serious game. In the Serious Play Conference [16] in 2018, traditional tabletop board games were revolutionized with the integration of the "serious" factor from serious games. A winner of the conference, Mission to Mars: An Agile Adventure [17] is a board game with the purpose of teaching Agile and Agile decision-making with the element of fun. With not much difference in the human to computer ratio, computerized serious games soon became popular. While it is supposed that games will have positive impact on education, not much research has been done in this topic. A study conducted to access the impact of games in collaboration among students (Bourgonjon et al. (2010)) showed that the games were helpful in developing collaboration skills. Sweedyk (2011) reported that students liked to play games and while some were more into games as compared to others, almost all of the 208 participants included in this study played games. This might contribute to the success of serious games in education.

[16] https://seriousplayconf.com/
[17] http://aspetraining.com/mission-to-mars-an-agile-adventure

2.4.1 Serious Games in Learning

With the purpose of learning while having fun, the present generation of students are more likely to play and learn from games (Michael and Chen (2005)). With its immersive nature, games can get students' attention for long time as compared to classroom lectures. Shikine et al. (2018) discusses the use of a serious game to teach and get students interested in mathematics. Serious games can be integrated with different educational domain. Some serious games are built specifically for the purpose of classroom environment, and they can cover a variety of study areas. Eordanidis et al. (2017) discusses about a serious game that is built to teach the concept of image representation to students. The study was conducted in a after-school program and concluded that the participants (girls) had an increased understanding of Image representation after playing the game. Colobot [18], with a blend of interactivity, storytelling, and programming, has been proved to be capable in teaching basic algorithms and commands similar to Java and C++ to teenagers. Dominguez-Rodriguez et al. (2016) presents two serious games, Pickit! and Cookit!, developed to introduce children from age 9 to 12 to nutrition education. Pickit! provides information related to the composition of food and the food supply chain, while Cookit! supplies the energy/calorie content and information related to healthy and unhealthy food found at home.

2.4.2 Serious Games over the years

With the evolution in the gaming industry, serious games are not an exception. The history of serious games have changed over time with the introduction of more advanced features in the games. Microsoft's Flight Simulator [19] is considered one of the most successful serious games of all time (Al-Riyami (2014)). Developed in 1982, newer versions of the game were still being developed till 2018. Flight Simulator was designed to provide detailed simulation to aviation and is one of the non-combat aviation games. Tiltfactor Laboratory [20], a serious game research centre established in 2003, are recognized as a big player in the serious game industry because of their innovative card games to represent three areas: public health, social attitudes and behaviors (Flanagan (2006)), and knowledge generation. Samovi (2018) states that **America's Army** is the best example of the use of serious games in military learning. Serious games are used in military training to create real-world environment using virtual simulation. The primary goal is to prepare soldiers to make decisions faster in real-world scenario. As stated by Laamarti et al. (2014), America's Army was developed by the US Army and

[18] https://colobot.info/

[19] https://www.mobygames.com/game/microsoft-flight-simulator-v10

[20] https://tiltfactor.org/

distributed free of cost online in 2002. The game simulates military training and missions to fulfill the goal of advertising the US Army and using the game as a recruitment tool for individuals aged 16 to 24.

Much work has been done in incorporating serious games to Computer Science and Software Engineering. The Serious Games for Computer Science project from Software Quality Research Lab [21] aims to improve learning in Computer Science and Software Engineering through game-based approach. RoboBUG (Miljanovic and Bradbury (2017)), an open source serious game, helps players to learn debugging techniques in Software Engineering through an enjoyable and motivating experience. Robot ON! (Michael A. Miljanovic (2016)) is an educational game designed with the focus of increasing the players' programming comprehension rather than teaching programming concepts. In this game, instead of writing a program, the players' tasks is to present their knowledge and understanding of the programs. Gee et al. (2016) presents serious games used to teach common Computer Science concepts to middle school children aged 11 to 13. Gee et al. (2016) discusses a digital puzzle game, GrACE, which is used to determine a graph's Minimum Spanning Tree (MST). The game play consists of animals collecting food while utilizing least effort. In a study conducted at the Brooklyn College and the College of Staten Island, Kletenik et al. (2017) focuses on using a serious game, Point Mouster, to teach advanced C++ programming concepts and to determine the impact of games to recruit and retain females in Computer Science.

[21] `http://www.sqrlab.ca/`

Chapter 3

Design and Development

In this chapter, we will discuss the design and development process of the application. Starting from problem description, the design process followed typical waterfall model alongside agile development methods which allows to make continuous iterations in developmental phase. The general strategy for application development can be seen in Figure 3.1. First, brainstorming process is conducted to determine the concept of the application (Section 3.1). This is followed by the next phase, Prototyping, in which the functionality and design aspects of the application are decided (Section 3.2). Finally, based on the prototype from Section 3.2, the implementation process starts where the application is developed (Section 3.3).

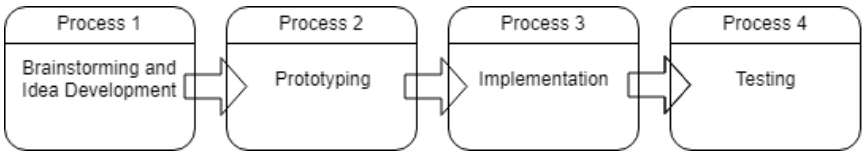

Figure 3.1: The application development process

3.1 Brainstorming and Idea Development

The work on brainstorming for concepts for the application started after the completion of the Systematic Literature Review. In this process, we took different ideas and concepts from earlier studies and made discussion and changes based on the demand of this project. The finalized concept had to be viable for completion in the given time frame. The project had no requirements and hence, we had

the freedom to develop any application that could be used to make an impact on preteen females' perception of Computer Science. Based on the Systematic Literature Review done during Fall 2018 semester, two concepts stood out from all the research articles: game play and game design. Game play included participants performing a playthrough of a serious game while researchers observed the session and conducted surveys to record the impact of the game play session. Game design sessions were designed in detail which provided participants with access to a platform where they could create games/animations/stories, and start-up tips on how to use the platform. Our immediate focus was to decide between game play and game design, and design the session accordingly.

3.1.1 Game Design vs Game Play

From the definition of Adams (2014), Game design is an act of designing a game along with its core elements such as user interface, rules, visual and auditory contents, and so on. In this project, the idea of game design originated from previous studies (Carmichael (2008), Miller and Webb (2015), Adams (2010) and Denner et al. (2012)) that used various platforms as Scratch, AgentSheets, StageCast Creator, GameMaker, and so on in order to teach Computer Science concepts to the participants. As discussed, one of the advantage of using a game design session is not having to develop any program, which is usually the most time consuming task. Additionally, when organizing a game design session, researchers need to create an information session in which all the activities planned in the session will be described to the participants.

Adams (2014) defines game play as an abstract feature of the game which consists of challenges for the player to overcome and the actions the player needs to perform such as role-playing, personalization, socializing with other players, and so on. For a game play session, researchers develop a game with functionalities through which they want to impact the participants. Some examples of game play sessions consists of Bonner and Dorneich (2016) and French and Crouse (2018) which resulted in increased interest of participants in Computer Science and increased chances of being indulged in a Computing career. Developing interest in some topic while having fun is one of the advantages of a game play session. However, the process of developing the application and implementing gamification elements in it is a primary challenge faced by the researchers.

Before choosing either game design or game play, we discussed the activities and information to share with the participants. As the objective of this thesis project is to increase preteen girls' interest in Computing careers, we aimed to include two main functionalities in our research study. First, we wanted to expose girls to female Computer Scientists so that they can relate themselves with the

Computer Scientists. Second, we wanted to teach a few basic Computer Science concepts which were mostly developed by female Computer Scientists. The idea of inclusion of these two features were central for the decision to design an application. After weighing the advantages and disadvantages of both game design and game play sessions, we opted in organizing a game play session. For this, the author needed to develop an application which integrates gamification elements. The idea for the next application developed by the author is described in the Section 3.1.2.

3.1.2 Finalized Concept: Media-integrated Quiz Application

First of all, we came up with a quiz game concept where the player had levels and would answer questions to gain points and level up. The concept also had leaderboard to show all the players and their scores. However, we felt a void in this concept as a number of such games were already built and the main goal: learning, was missing. In order to add learning element into the application, the application had to go certain changes in the conceptual phase. Later, the decision to add media content in the application was made. The application was to be build in two parts: first, the idea was to develop videos of female Computer Scientists, their professional career in brief, and their major contributions in the field, and second, these videos are integrated in the application and based on the information in the video, participants answer the quiz. The videos are responsible for teaching basic Computer Science concepts to the participants. With the videos, the aim is to provide female participants with female role models to relate to, and with the quiz, we aim to observe if the participants learnt the Computer Science concepts that they were briefed in the video.

There were some more extension to this concepts. One such extension was to develop the application into a serious game by incorporating all the six design choices (gamification elements), namely, strong female presence, engagement and flow, leaderboard, personalization, collaboration, and educational factor. However, due to the time constraint on the duration of the project, we were unable to take all the elements into consideration. The application makes use of media (videos) with educational motive to reach preteen girls and tries to increase their interest in Computing industry. There were few other ideas which came up when discussing the idea in detail. We shall discuss them later in the thesis report as none of them made the cut for development phase.

3.2 Prototyping

Two types of prototyping methodology is used in this stage: a paper prototype and a working prototype.

3.2.1 Paper Prototype

A paper prototype is one of the most used types of prototyping when developing an application in Software Engineering. This type of prototyping is mostly used in the early conceptualization phase (Babich (2018)). Paper prototyping is a cheap, fast and fun process which follows rapid iteration, meaning, one can create different versions in a matter of minutes. The use of paper prototyping in this project is done in order to outline the steps in a user flow and to visualize basic layouts of the application. Additionally, we preferred paper prototyping in the early stage so that we could make necessary changes as soon as possible without having to waste more time.

Figure 3.2 shows the paper-drawn home screen of the application which contains video which is paused at the beginning. The player plays the video and after the video ends, the space taken by the video disappears and a quiz begins there as seen in Figure 3.3. On the top right of the page, a picture of the user, representing the user avatar, is located which is accompanied by user's scores. Figure 3.4 shows the total score of the user and an option to restart the quiz.

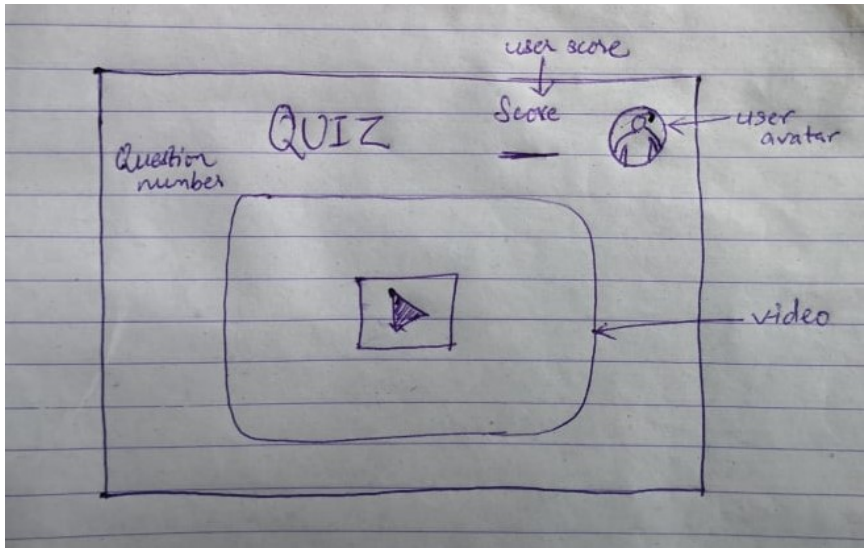

Figure 3.2: Paper-based visualization of the home screen along with various application components

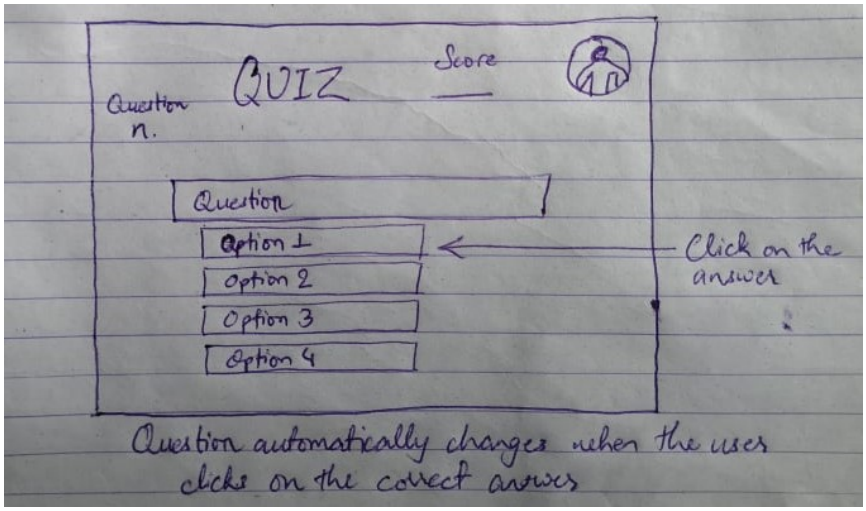

Figure 3.3: Paper-based representation of the quiz component

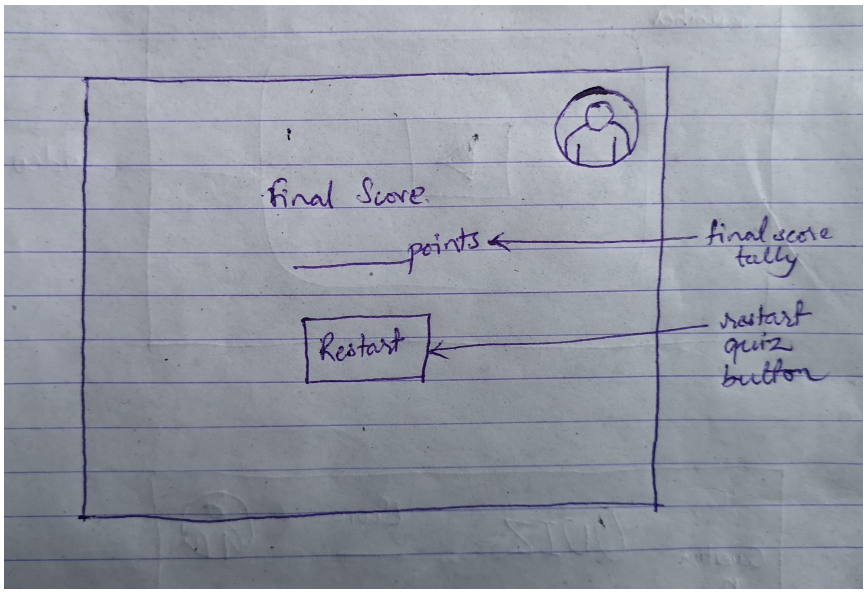

Figure 3.4: Paper-based visualization of final tally of the quiz application

3.2.2 Working Prototype

After the paper prototyping, a working prototype was built which provided some primary functions, such as quiz model, but was far from a final product. The

prototype was built in React [1], a Javascript [2] library developed by Facebook, from scratch.

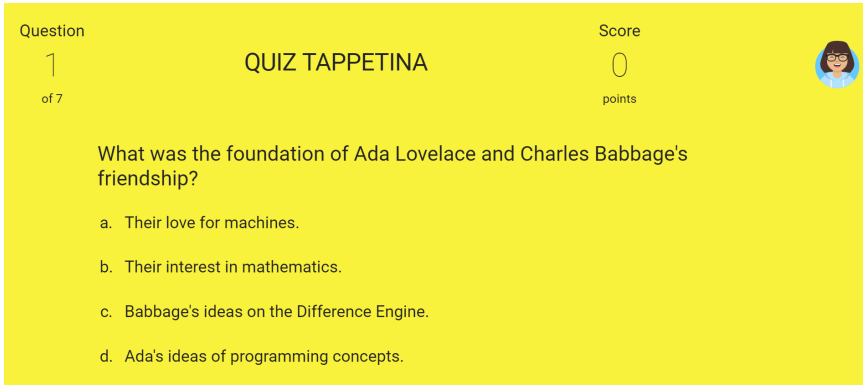

Figure 3.5: Screenshot of the working prototype showing quiz model

The quiz model and the home screen of the working prototype can be seen in Figure 3.5. The questions are selected at random, and the user gets two opportunity to answer the question correctly. If the user fails to get the correct answer by the second attempt, at most, any other attempts will provide zero points. This is how points system is maintained in the application.

Additionally, for the development of the final product, two female Computer Scientists, Ada Lovelace [3] and Betty Holberton [4], were selected and videos were created on their professional life and contributions. The videos for Ada Lovelace and Betty Holberton and their contributions in the field of Computer Science can be found in "Ada Lovelace and an Introduction to Loops" and "Betty Holberton, Computer Debugging and Breakpoints" respectively.

3.3 Implementation

In this section, we shall discuss the development of the application from the perspective of a Software Engineer. This phase started after paper prototyping with minor changes in the design and concept of the application. The main priority in this phase was to develop an application with various functionalities that could address the problem stated in this research study. One such functionality was to

[1] `https://reactjs.org/`
[2] `https://developer.mozilla.org/en-US/docs/Web/JavaScript`
[3] `https://24094361.weebly.com/ada-lovelace.html`
[4] `https://24094361.weebly.com/betty-holberton.html`

integrate media and quiz in such a way that participants could learn new Computer Science concepts by watching the videos.

3.3.1 Choice of Technology

After one point in the design and development of a project, mostly after prototyping, the developers face a major task of choosing the technology. In most cases, this task is taken as a challenge because of the presence of numerous technology one can choose, and, additionally, the developers have to outweigh the pros and cons of technologies with each other to determine the most appropriate technology for developing the application. The chosen platform had to be quick and easy to learn and use in order to start the project as soon as possible. Since the idea for the quiz application was conceptualized in the form of a one-page application, one choice for technology was to use HTML and Javascript only. This, however, changed later because of the possibilities provided by various Javascript libraries which were taken into consideration. Other possibilities for platform was Java since the author had relevant experience in developing web applications in this platform. However, with Java, the author had to maintain multiple applications, for example, a web-based user interface, an Application Programming Interface (API) developed in server-side, and a database to hold the data such as the links to the videos and the quiz questions and answers. Therefore, Java was discarded from the choices. Finally, React Javascript library was selected as the platform because of its features such as code reusability, easy migration to other platforms, and lightweight (Mahmood (2018)). Likewise, Heroku [5] was used for deploying and managing the application online.

React.js

One of the main reason to choose React is the author's experience in Javascript and HTML, and React's developer friendly web community in case of any problems during developmental phase. Additionally, the application is built as an website and is accessible from any compatible browser, desktop or mobile devices. No downloads would be necessary to run the application. React is also an open source platform which is found freely in the internet.

React's capability to fetch and change data rapidly was also responsible for selection of this platform. As mentioned above about application developed in React's integration with other platforms, we plan to integrate this quiz application with the original website of Tappetina Ecosystem, hence, making this application a product under the ecosystem. Easy to modularize other applications (Mangin

[5] `https://www.heroku.com/`

(2018)) in React is also a feature that can come in handy in future development of this application. This functionality provides the developers to create functionalities as modules which can be used by other applications. For example, a login module developed in React for application A can also be used by another application, say B. Other examples of applications that can be modularized in React are Security, Library, Analytics, Payments, Search, Basket, Emailing, Live Chat, and so on.

Heroku

Heroku is a cloud-based platform which supports deploying, running and managing application developed in various programming languages. Initially, when founded in 2007, it only support Ruby [6] programming language, but today it supports Java, Python, Node.js, Scala, Php, and Go (Heroku (2018)). Heroku equips the developers with runtime environment and application servers for the programming languages mentioned above which makes it easy to use.

Deploying an application in Heroku removes developers from the trouble of installing an application server and running the application in it. This task alone is tedious and meticulous since the developers have to pay attention to minute details. Additional effort to maintain the server from time to time is also eliminated. Deploying and running the application in Heroku is made fairly easy with the addition of pre-build and post-build script in package.json file on a Node.js application. Other features for choosing Heroku for deploying the application (Sviatoslav (2018)) includes application rollback: rollback to a previous state, application health monitoring: application metrics showing resources used, recent activity and analytics, and full github integration.

Microsoft PowerPoint, Abode Premiere Pro

The author used Microsoft PowerPoint to create the videos. Adobe After Effects [7] was the first choice to create animated videos, but due to time constraint and the author's lack of experience in that particular tool, the idea was discarded. Also, for videos which uses mere texts and images, PowerPoint seemed like a reasonable choice. The videos were created using PowerPoint, but producing matching audio for the videos was another challenge the author had to tackle.

Various online free text-to-speech tools were tried to generate audio that was to be integrated into the video. Some of the tools are Animaker [8], NaturalReader [9],

[6] https://www.ruby-lang.org/en/
[7] https://www.adobe.com/products/aftereffects.html
[8] https://www.animaker.com/
[9] https://www.naturalreaders.com/index.html

and TTSReader [10]. The audio thus generated were edited, made consistent with the video, using Audacity [11], an open source audio software. Finally, Adobe Premiere Pro [12] was used to edit and render the video suitable for uploading in YouTube. Adding voice-over to the video was done via Premiere Pro. Since the videos contained texts, understandability was a feature important for the videos in YouTube. Adobe Premiere Pro enables the user to generate high resolution video suitable for YouTube. The author also had prior experience in using Premiere Pro which motivated in selection of the software for video editing.

Github is used as a version control tool which enables the developer to control the source code of the application. Through Github, the developer can track changes made in the code from time to time. Version control tools, such as Github, enables the developer to rollback and check earlier versions of the code in order to fix mistakes. Likewise, Github facilitates multiple developers to work in different parts of the same project simultaneously.

3.4 Description of the Quiz-application

3.4.1 About the quiz

The application developed in this thesis is a quiz-application which enables players to watch videos and answer questions. The videos used in this application are specially created in order to provide information to the players (dominantly, preteen girls). The videos introduce female Computer Scientists and their notable contributions in the field of Computing industry to the players. The questions in the quiz are based on the information provided in the videos.

In Woit and Mason (2000), the researchers used online quizzes in first-year students' Computer Science courses as an alternative to weekly laboratory assignments, and the results obtained showed an improvement in students' learning and retention. The quiz introduced in this thesis is similar to "Reflection Quiz", as defined by Pirker et al. (2014), which are used to track the progress of the participants over-time. The quiz-application aims to impact preteen girls' interest in Computer Science by introducing them to female Computer Scientists to show that "Anybody can do Computer Science" and break negative stereotypes. The desired outcome is to teach two Computer Science concepts (loops and debugging) that are significant in programming, and increase girls' interest towards Computing careers.

[10] https://ttsreader.com/
[11] https://www.audacityteam.org/
[12] https://www.adobe.com/products/premiere.html

3.4.2 Gameplay

The quiz can be played online at "Tappetina Quiz" and is accessible from any local network at all times. Figure 3.6 shows the screen of the quiz when it begins. The top left of the screen question the number of question, the top left shows player's points and avatar, and the space in the center is used for showing the main content of the quiz, which at the starting state is the video (as shown in Figure 3.6). After the player finishes watching the video, the quiz will automatically start. The question will be shown in the space allocated for the video in Figure 3.6. This can be seen in Figure 3.7. The quiz has no time limitation, meaning the user can take as much time as needed to answer the questions.

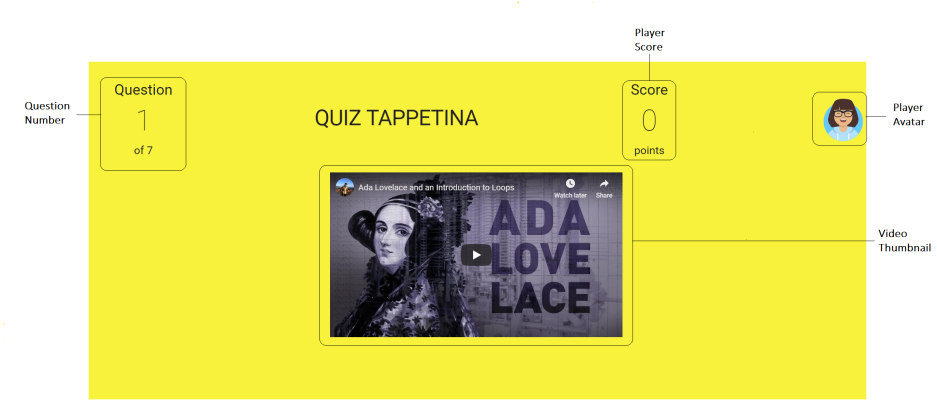

Figure 3.6: Screen capture 1

The quiz progresses with every correct answer. The player gets to choose the options as long as they do not find the correct answer i.e for 4 times. However, the player will be rewarded with points only if the player correctly answers a question on the first or the second try, while correctly answering a question on the third or the fourth attempt does not provide any score. This is done not only to show the player the correct answer, but to show them which answers are incorrect as well. Answering the question on the first try provides the player 10 points, while answering on the second try get only 3 points. This feature was created to motivate the player even if they do not get the correct answer in the first attempt. Finally, after all the questions are answered, the player will get their scoresheet listing the total points, number of questions answered in each attempt (as can be seen in Figure 3.8).

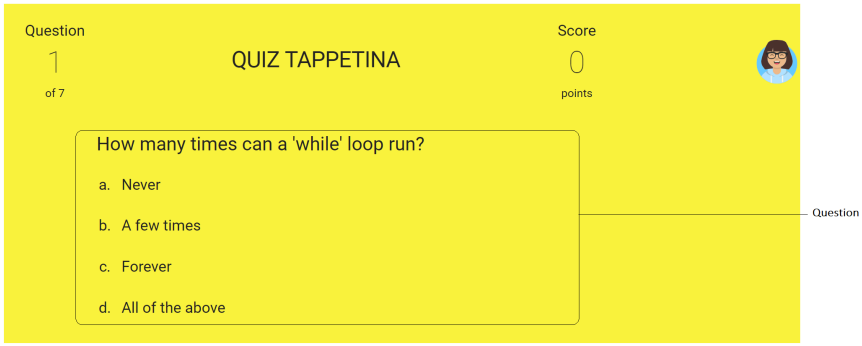

Figure 3.7: Screen capture 2

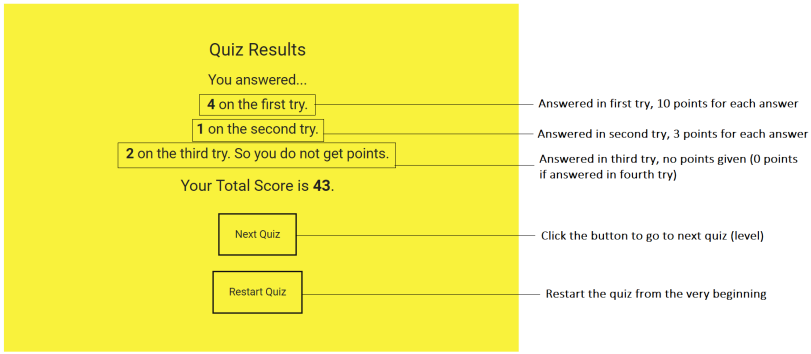

Figure 3.8: Screen capture 3

Chapter 4

Evaluation

In this chapter, we will discuss and evaluate various research strategies and present the results. The research strategies used in this thesis are taken from Oates (2006). In Section 4.1, various research strategies that can be used for this thesis are discussed. This is followed by data collection methods in Section 4.2. The process of planning the evaluation along with the selection of participants is described in Sections 4.3 and 4.4 respectively. Finally, the results based on analysis of collected data is presented in Section 4.5.

4.1 Research Strategy

To determine the strategy to conduct research in this study, we examine the different empirical strategies described in the book "Researching Information Systems and Computing" by Briony J Oates (Oates (2006)). Different strategies discussed by Oates are Surveys, Design and Creation, Experiments, Case Studies, Action Research, and Ethnography as can be seen in Figure 4.1. These strategies are used in research studies to determine the required knowledge/information. These strategies also helps to describe why gathering information in the study is necessary, and what is the use of the information once it is collected. Likewise, Oates (2006) also provides an structured plan to conduct the research study, an approach to deliver the results, and how to answer the research questions. Before making the decision on which research strategies to use and why, lets take a deep insight into reach of the six strategies.

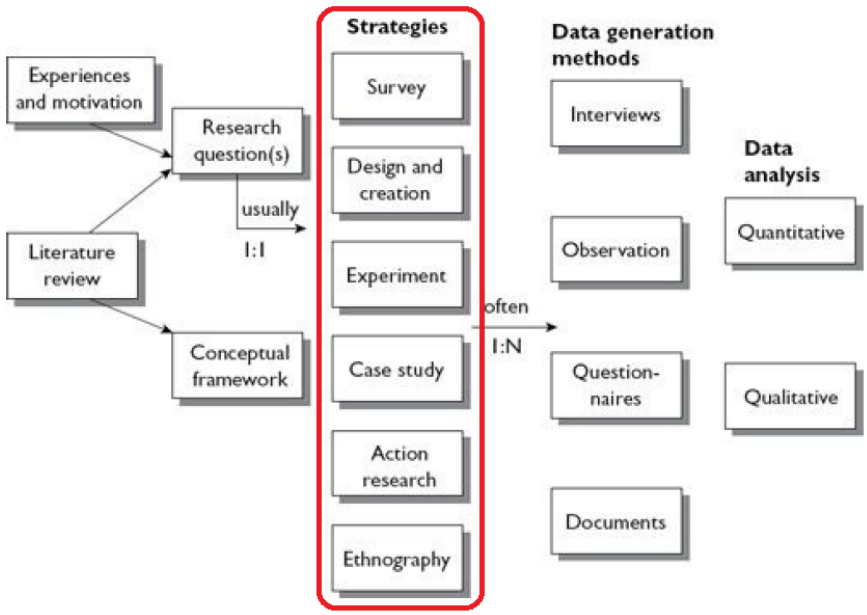

Figure 4.1: The research process model (Source: Oates (2006))

4.1.1 Surveys

A survey is used to collection similar data from a large group of people in a standard way which is then generalized to a larger population through patterns of data. A misconception that exists in surveys is that many people assume surveys consist of questionnaires as data generation method, but surveys are also possible using interviews, observations and documents. Oates (2006) also informs the readers on online surveys which can be conducted by emailing questionnaires to participants, or by asking people to visit a webpage and complete the questionnaire. In this thesis project, a survey can be used to evaluate the quiz application and get an insight on how the application can be used to impact females' perception. While a questionnaire is unable to generate this information, additional strategies like interviews can be used to comprehend the impact more directly.

4.1.2 Design and Creation

According to Oates (2006), a design and creation strategy focuses on designing and developing new IT products, also known as artefacts. March and Smith (1995) discusses that an IT artefacts includes a combination of construct: entities, objects or data flows, model: data-flow diagram, use-case scenario or a storyboard, method: production models and processes in problem solving, and instantiation: demon-

stration of constructs, models, methods, ideas, etc implemented in computer-based system. In this strategy, the application is a part of the contribution to the research. The design and creation process involves innovation alongside learning. This premise seems fit for this thesis project as the application will mainly contribute in learning. According to Vaishnavi and Kuechler (2004), the design and creation process follows an iterative problem-solving approach which involves five steps: awareness (recognition and description of the problem), suggestion (ideation on how the problem can be addressed), development (implementation of the tentative design idea), evaluation (assess the artefact, its value and deviations from the original idea), and conclusion (description of the results, identification of knowledge gained and subject to future research).

4.1.3 Experiments

An experiment in a research study is performed in a closed environment, like a laboratory, to gather controlled (based on strict requirements) data. The main purpose for which an experiment is designed is either to prove or disprove a hypothesis. In any research study, to achieve better results, researchers conduct the experiment multiple times in order to draw firm conclusions. An experiment is the best way to make precise and detailed observation of outcomes and/or changes that may occur in the research because of varying factors. If this thesis project wanted to measure the precise level of impact of the application, then controlled experiments would definitely be the choice. However, for such an experiment, this project lacks the factors and in most cases, the factors are not controllable. For example, the environment in which the experiment is conducted affects the number of participants, and there is no immediate way to tell how the environment affects the participants until the experiment is carried out. Another difficulty with experiments are their controlled nature which in reality is unlikely to exist.

4.1.4 Case Studies

A case study, as presented by Yin (2003), can be defined as an investigation performed in a real-life context which includes multiple factors and relationships that helps to obtain detailed insight of the case. Yin (2003) presents three basic types of case studies: exploratory (used to define questions or hypotheses that can help understand the research problem), descriptive (provides detailed analysis of a particular context including the study and how participants perceived the study), and explanatory (describes why certain events occurred and their outcomes, and also compares the theories present in the literature with the case). For a detailed analysis through case studies, researchers usually follow a longitudinal approach where investigation is done for several months to years to analyse continuous and

changing processes and relationships. For this thesis project, a longitudinal case study would seem to provide a viable outcome as the application can be used with changed settings to observe and compare the results. However, the challenge to recruit same participants in multiple cases poses a risk to the case studies. A disadvantage to using a case study research strategy might be researcher biasedness where the presence of a researcher might affect participants' behavior leading to inability to study the intended effect.

4.1.5 Action Research

Researchers perform action research to investigate and improve their own working practices in research studies. Oates (2006) reveals that this approach is focused on practical issues as opposed to hypotheses and experiments, and addresses real-world problems faced by the people. Action research strategy is based on making a difference and learning about how the change was affected by the research. This strategy focuses on how groups work, and changes are made to a situation in order to find better course of action which is why this strategy does not fit the research criteria of this thesis project.

4.1.6 Ethnography

In general terms, ethnography is a study of people and cultures. In this strategy, researchers observes the society from the perspective of the study. Ethnography implements a data collection method where the researcher examines and interprets participant's behavior in a certain social situation. As this research does not bias participants based on their cultural and social identity, this strategy fails to address the research requirement of this thesis project.

Finally, a design and creation strategy is selected where the focus is an application as an IT artefact. The contribution in this strategy consists of the development and evaluation of the application. Innovation in this strategy constitutes designing the application alongside the processes and frameworks used in the development process, and evaluating the developed application via user trials. For the evaluation of the application in this project, we discuss various data collection strategies in Section 4.2.

4.2 Data Collection Methods

In order to find the answers to a research problem, test hypotheses, and evaluate outcomes, researchers have to collect data from relevant sources. Oates (2006)

presents four methods of data collection, namely, interviews, observations, questionnaires, and documents. The selection of data collection methods are directly linked with the selected research strategies. Since the selected strategy in this thesis is design and creation, and this strategy focuses on design process only with no involvement with the users of the application directly, this, therefore, creates a need to identify and choose other strategies for evaluation through users. This creates a need to decide data collection methods appropriate for the project. The selected data collection methods should be able to grasp in-depth information so that data analysis can show principal outcomes of the application on the participants. The questions present in the questionnaire can be seen in the **Appendix B** in Table 6.3.

4.2.1 Interviews

Interviews are planned discussion which are organized by researchers in order to gain detailed information from the participants. Usually, an interview consists of a set of questions asked by the interviewer while the interviewee answers the questions. There are not any particular formats or methods for the answers in an interview, as opposed to questionnaires. According to the types of questions asked, interviews can be of three types. An structured interview consists of a planned discussion, a semi-structured interview has room for some unplanned discussions with open-ended questions, and an unplanned interview, which is also compared to a normal conversation, does not consist of any planned questions. In terms of organization, interviews can be of two types, namely, individual interview (during the time of the interview, only two personnel are present, the interviewer and the interviewee), and group interview (one interviewer holds the interview session with multiple interviewees at the same time). Individual interviews were planned for the evaluation in this thesis project because interviews provide deeper insight into the participants' thoughts and feelings about the application and the session. The interview consists of planned questions which can be seen in the **Appendix C** in Table 6.4.

4.2.2 Observations

Observations are a form of data collection method where the researcher stands by the sideline and watches and takes notes as the participants are engaged in the activities. Oates (2006) defines observations as "to watch" and "pay attention", and is related with everyday tasks like seeing, hearing, noting, analysing, forming theories, and making inferences. Observation is used to find out what participants do rather than what they report when questioned. The researcher must be immersed into the context to gather information in a social situation from the observation.

Observations can be both, structured and unstructured. Structured observations are planned on what to observe and when and how. Unstructured observations are unplanned and does not include any schedule. In this thesis project, observations play a key role if the participants are preteen children. This is because with the kids, it is beneficial to note their actions when they are using the application. Since the range of information to record is somewhat uncertain at this point, the observation would be partly structured and partly unstructured.

4.2.3 Questionnaires

A questionnaire consists of pre-defined questions placed in a certain pre-defined order to collect data for analysis and further interpretation. Questionnaires are the most widely used survey research strategy where a questionnaire is sent to the sample who then fill it out and send it back to the researcher. The researcher analyzes the questionnaires to determine patterns and make generalizations to larger population. According to Oates (2006), questionnaires can be "self-administered" - the participant fills it out without the researcher, and "researcher-administered" - the researcher asks questions to the participant and notes the responses. Questionnaires are also a flexible and simple way to record individual responses. Questions in a questionnaire can be "open" where the participant can respond as in their own words, or "closed" where the participant has to select one or many of the predefined answers. In this research project, as the questionnaires were online, they consisted of mostly closed questions. Additional support for the interpretation of the data collected from the questionnaire was done by individual interviews of the participants.

4.2.4 Documents

Documents are a data collection method includes using existing documents (articles, reports, book, and so on) to find the necessary information. Documents as a data collection method are used alternatively to interviews, observations and questionnaires. Documents are divided into two types: Found documents - documents that exist prior to the research being conducted (eg, literature), and Researcher-generated documents - documents that are put together for the particular research and did not exist prior to the research (eg, notes, photographs). To answer the research questions in this thesis project, we rely a lot on documents, be it found documents such as the literature addressing the research problem, or researcher-generated documents such as analyzed and interpreted information from participants and the prototypes developed in the design phase. One challenge the researcher can face when using documents in the research is its credibility and assistance in achieving the research goal. In order to tackle this challenge, the re-

searcher should rely on literature from esteemed authors and that are more referenced.

4.3 Planning the Evaluation

In this section, we shall discuss the plan for evaluating the research. Initial plan stated that the evaluation will be held with preteen girls (aged 8 to 12) in a local school. The participants would be evaluated based on how they explore the quiz application, observation, questionnaires and interviews. Alternate plan for evaluation involved professionals in the field of Computer Science (mostly masters student at university level, PhD candidates, and Postdoctoral candidates) who are currently active in the domain. The purpose of this evaluation plan was to get expert's opinion on the application and its aspects, and whether it fulfills the objective of the thesis or not. This would be beneficial for further development of the application to make it more appealing to the participants and practical in order to achieve the objective of the research.

The plan includes various considerations and expected outcomes made throughout the research. At the beginning of this research, pre and post questionnaires were chosen as data collection method. The participants would be asked to fill out the pre questionnaire which included questions through which researchers could understand participants' perception on Computer Science before the participants go through the quiz application. A post questionnaire was planned to be filled by participants after they play the quiz application. Both, pre and post, questionnaires had some repeated questions to study the impact of the application on the participants. The questionnaires were also used to visualize direct correlation in participants' age and their perception toward Computer Science. The responses from the questionnaire would be analysed both, qualitatively and quantitatively. Qualitatively because of the nature of the responses which are more general then statistical, and quantitatively because some questions' answer were numerical, for instance, a likert scale ranging from 1 to 5. However, conclusions from quantitative analysis were also made qualitative.

The data collection methods planned for this research were questionnaires, observation, and interviews. The observation is done in the session where the participants go through the application to notice and note things that cannot be visible in the questionnaires filled out by the participants. The main purpose of the observation is to note "How long the participants take to answer the questions?", "Do they have any difficulty in understanding the content of the video used?", and "Are they facing any trouble with using the system?". However, during observations, participants sometimes act differently in the presence of the researcher which may lead the researcher towards conclusion which is, in truth, fake. But, this inconsis-

tency can be removed by comparing the information collected from observations with the responses from the questionnaires and interviews. This will remove inconsistencies and generate results that can be generalized to a larger population.

Another data collection method in this research, interviews, are used to get a more detailed insight and feedback from the participants. Individual interviews are planned with the researcher as the interviewer and a participant as the interviewee. For the interviews, willing participants are selected at random. Two important aspects are studied through the interview, impact of the application on the participants and feedback from the participants for further refining the application. The interview are semi-structured, meaning that some aspects of the interview are already decided, for example, questions on choice of education of participants in future, design aspects of the application which needs more work, and so on, but the interview is also unrestricted for open discussion. Through the interview, the researcher can gain participant's thoughts and perspective that could not be recorded via the questionnaires.

Research papers employing the research strategies and guidelines discussed in this chapter have been studied by the author of this thesis during the Systematic Literature Review in Fall 2018. Some varying factors in those studies were the environmental contexts of the study such as After School session, Workshops, Summer/Winter Camps, and Classroom curriculum. AlSulaiman and Horn (2015), Robinson et al. (2015), Stewart-Gardiner et al. (2013), Eordanidis et al. (2017), Groover (2009), Spangenberger et al. (2018), Bonner and Dorneich (2016), French and Crouse (2018), Esper et al. (2013), and AlHumoud et al. (2014) had activities where participants had to explore an application. They used mixed methods for data collection which mostly includes questionnaires, interviews and observations. These research were performed with a common focus that is to study participants' interest in Computer Science before and after the session. Among the studies mentioned above, only AlSulaiman and Horn (2015) failed to show positive results i.e. increased interest in studying Computer Science or choosing a career in Computing, and showed no change in participants' interest.

Due to the short timeline of this thesis project, further research in future would definitely provide authenticity to the outcomes of this research. Also, research conducted over a long period of time could yield valid results and conclusions which would provide valid results with large sample population too.

4.4 Participants and Event

An informal event was held for the evaluation of the research which consisted an online evaluation with professionals of Computer Science as discussed in Section 4.3. The researcher was unable to evaluate the application with the focus group

i.e. preteen girls aged 8 to 12. This poses a challenge to the outcome of the research as the results will now include Computer Science professionals' ideas and understanding of the research which will in some way be different than preteen girls'. However, this also provides a positive path for the research i.e. with the feedback from professionals the application can further be developed and refined before a gameplay session with preteen girls. The online evaluation consists of exploring the application, answering a questionnaire, and interview (voluntary). Only few candidates were able to participate in the individual interview which was conducted through Skype [1] while the researcher took notes. The course for an online evaluation was taken because of the challenge to gather professionals at one spot at the same time. At the time of the evaluation, universities, where most of the sample population are located, had examinations and thus, it was difficult to organize a meetup. Likewise, the researcher could not meet every participant personally and conduct the session, hence, an online evaluation session deemed the most suitable.

With the ambition of 50 to 100 responses from professionals, the evaluation phase began. The participants that responded ranged from 20 to 35 years of age while the researcher had expected participants of range of 25 to 55 years. Most of the participants were contacted via email. The email was composed of links to the application and the post-questionnaire. Apart from the questionnaire, another survey for System Usability Scale (SUS) was attached for participants to fill out. While the survey for SUS was not compulsory, not many participants responded to it. The email sent to the candidates had general information of the thesis project and the Tappetina Ecosystem, the application and some "how to" information related to it, instructions on when to fill out the questionnaire, and finally, attachment of the NSD application so that the participants can read more about the thesis project and how the information they share will be used in the thesis report.

By the end of May, a total of 76 responses were achieved from the participants. Achieving all the responses by the sole effort of the researcher was difficult, therefore, help from researcher's colleagues are also responsible for reaching that number. Participants were an origin of various nationalities which we discuss in the results in Section 4.5.

4.5 Results

In this section, we will discuss the outcomes of the analysed data. The data were collected from 76 individuals from questionnaires and interviews. In this section, we visualize the outcomes, and assess and generalize it to a larger population.

[1] `https://www.skype.com/en/`

4.5.1 Participants and their background

The analysed data, in Figure 4.2, showed that 57% participants belonged to the age group 25 to 30. This might be a result of the researcher association with masters degree students, most of whom fall in this age group. Figure 4.3 shows the participants according to their gender. 58% men participants were men while the rest 42% were women. A quick generalization made from this statistics show that the result does not depend on participant's gender or age.

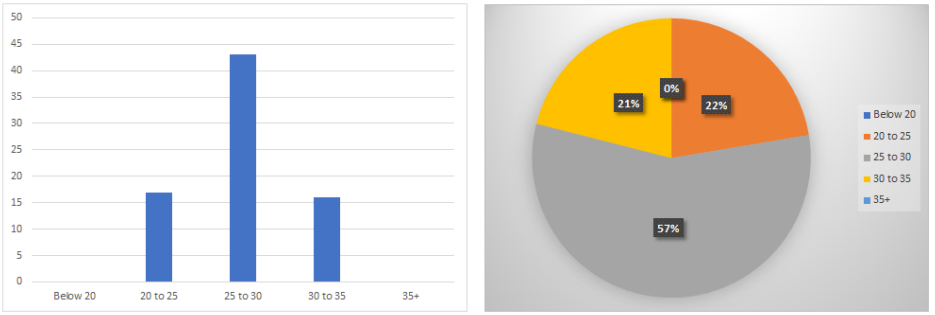

Figure 4.2: Age distribution of the participants

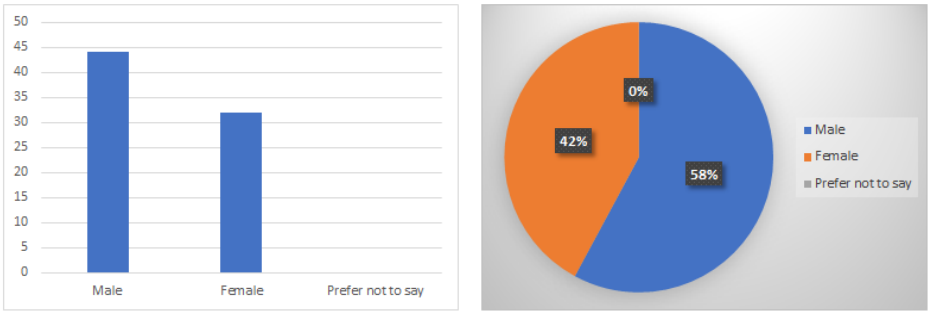

Figure 4.3: Gender distribution of the participants

The participants in this research participated from more than seven countries from all over the world, which can be seen in Figure 4.4. Among these, Nepal, USA and Norway contributed with the most number of respondents with 16, 13 and 12 respectively. This diverse involvement shows the intricate problem issued by this research and is likely to generate interest from professionals all over the world. In order to access participants' background, one question in the questionnaire was "Are you currently involved in some area of Computer Science?", and the results (in Figure 4.5) show that 82% of the respondents were involved in some

area of Computer Science while the rest 18% were not. This shows the interest of people from fields other than Computer Science. And, since, women are underrepresented in mostly all areas of Sciences, additional interest from individuals involved in fields other than Computer Science is a positive path for this research.

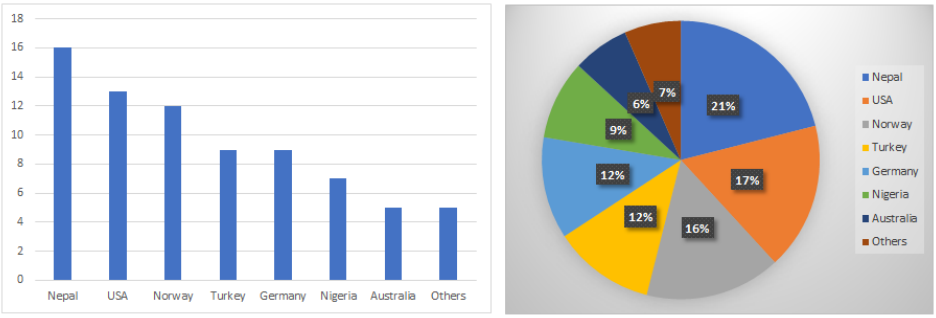

Figure 4.4: Nationality of the participants

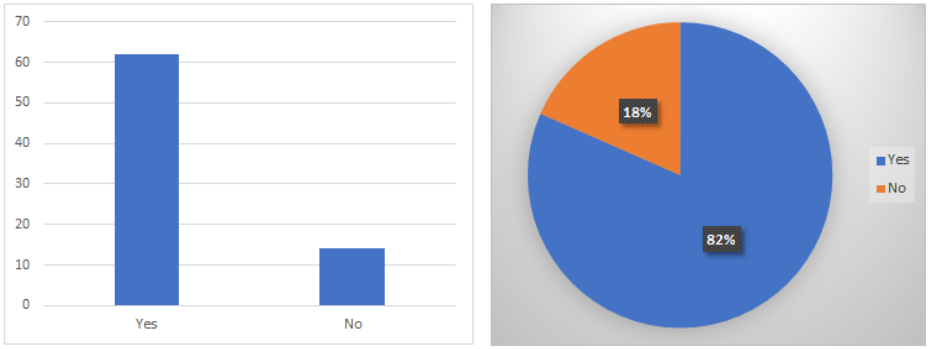

Figure 4.5: Involvement of participants in Computer Science field

4.5.2 Participants and their perception on increasing girls' involvement in Computing careers

We asked participants if projection of Computing careers to preteen girls by female role models would be more effective in increasing their interest towards Computer Science, and 84% participants responded positively (seen in Figure 4.6). This shows the positive direction the research has taken by introducing female role models and their contributions to the field of Computer Science regardless of the difficulties faced by them in the field. By informing the hardship the female role

models went through to work in Computer Science during their time, we want to make the girls have a sense of confidence in them to approaching Computer Science careers. The researcher also wanted to understand participants' willingness to encourage or mentor young girls to enter Computer Science field. The outcome, in Figure 4.7, shows that 72% respondents were ready to mentor young girls to increase their interest in Computer Science field. The rest of participants who responded with either "Maybe" or "No" are likely to be participants who are not involved in Computer Science currently.

One participant said: *"Informative sessions like impacts on a person's interest towards a certain topic because, for example, in this session, introducing female Computer Scientists is a way to tell girls "You are not alone in this industry", and this is likely to develop a feeling of security."*

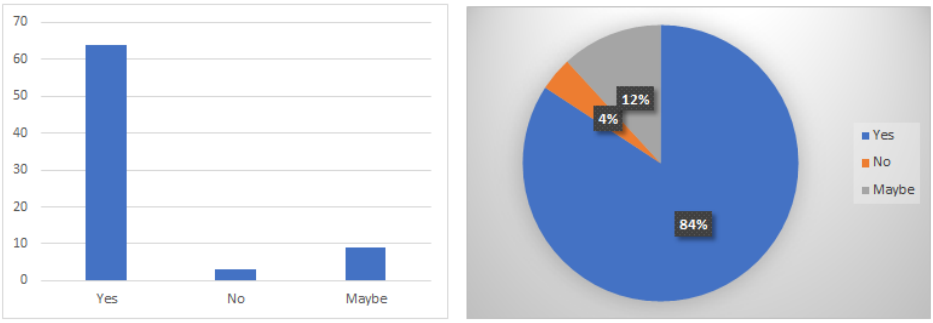

Figure 4.6: Having female role models to project career situations is critical to opening doors for girls to consider career in computer science

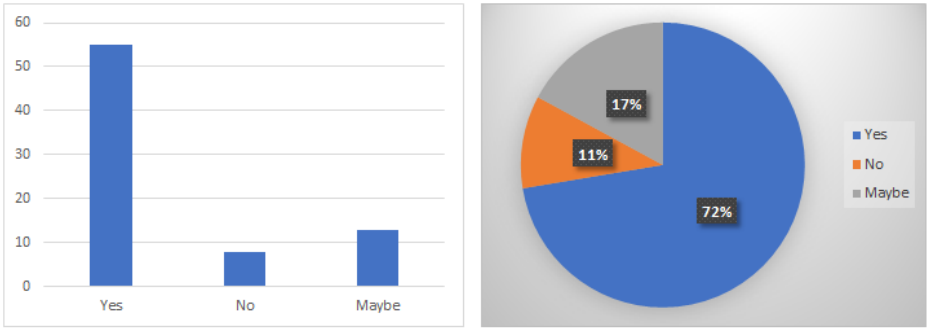

Figure 4.7: Participants' willingness to mentor/encourage girls to enter Computer Science

4.5.3 Participants' evaluation of the application and its objective

A similar study conducted by Bailie (2015) used printed booklets with information of female Computer Scientists and current trends in Computer Science to increase students' interest in Computer Science. The study failed to take feedback from the focus groups but the teachers to whom the booklet was presented provided positive feedback. The demand of the booklet also rose than predicted. Similar to Bailie (2015), this research also collects feedback from professionals in Computer Science. When asked if applications and sessions like this will increase preteen girls' interest in Computer Science and eventually influence them in choosing a Computing career, Figure 4.8 shows that 60% respondents provided a positive feedback while 28% were unsure of the such generalizations. Additional query on whether basic Computer Science concepts can be taught to young minds via digital technologies such as games and educational applications, a total of 92% respondents agreed and only 8% disagreed, as shown in Figure 4.9. This shows the participants' optimism and confidence regarding this research topic and its objective. The outcome also shows that the participants are convinced that educational applications and games can be used to increase the participation of young females in Computer Science.

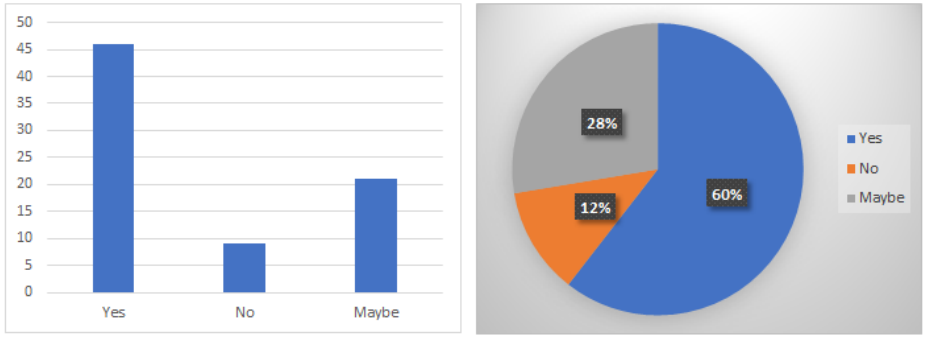

Figure 4.8: Sessions like this will influence young girls' decision to choose a career in some area of computer science or information technology.

One participant said: *"I would agree that applications like this can increase preteen girls' knowledge in Computer Science. Because this application, in particular, tries to teach a basic concept,* ***Loops****, which are not complex and can be described orally or with few examples. However, applications like this can experience numerous difficulties when teaching complex concepts like searching algorithms or machine learning."*

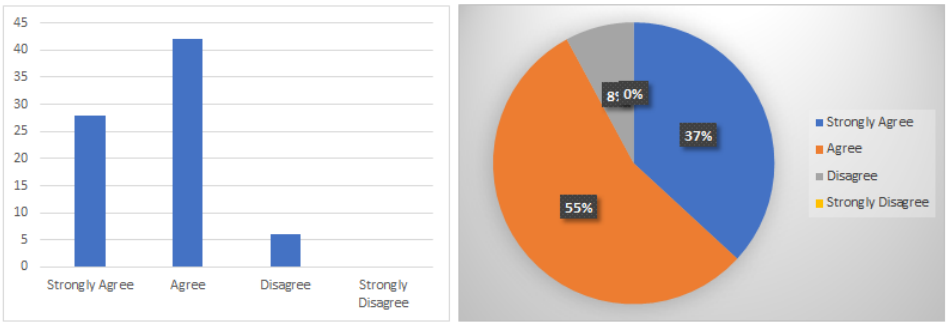

Figure 4.9: Sessions like this will help preteen girls learn basic Computer Programming concepts.

Participants were also asked to evaluate the concepts that were present in the videos. They had to rank the level of difficulty of the concepts (loops, bugs and debugging) for the focus group of the research. Figure 4.10 shows the level of difficulty to learn the basic concept of looping in Computer Science via the quiz application. 55% reported that it was "easy" or "very easy" to learn about loops through the quiz application while 45% said it was either "somewhat difficult" or "extremely difficult". Additionally, teaching young girls about Programming Bugs and Debugging via video in the quiz application discussed in this research resulted in 86% responses in "extremely difficult" or "somewhat difficult", and only 14% answered "easy", as can be seen in Figure 4.11. This difference in result might be because bugs and debugging in programming are actually broad and complex concepts. The mixed review from the participants reveals that the activities should be more simplistic so that young girls with little to no knowledge in Computer Science can learn from them. This also shows that the videos in this application are meant for introducing those concepts to young girls, and teaching Computer Science concepts through videos is somewhat complex than expected.

4.5.4 Design Factors and suggestions for further development

At the beginning of the thesis project, the idea was to develop an application and implement various design factors and gamification elements, that we concluded in the Systematic Literature Review in Fall 2018, to modify the application into a game. While this idea could not be implemented as a whole, the researcher put an effort to implement few factors which could be crucial for the progression of the application. When asked "Which design factors did you find in the application?", 38% participants responded "Educational factor" and another 37% responded "Strong Female Presence", as can be seen in Figure 4.12. This shows

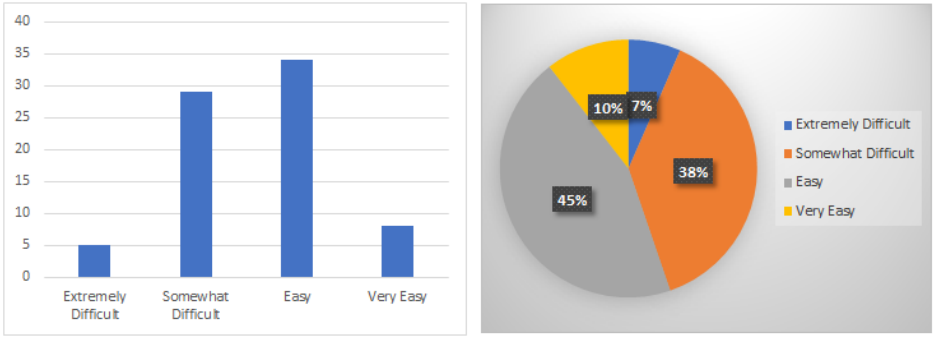

Figure 4.10: Level of difficulty to learn about Loops via this session

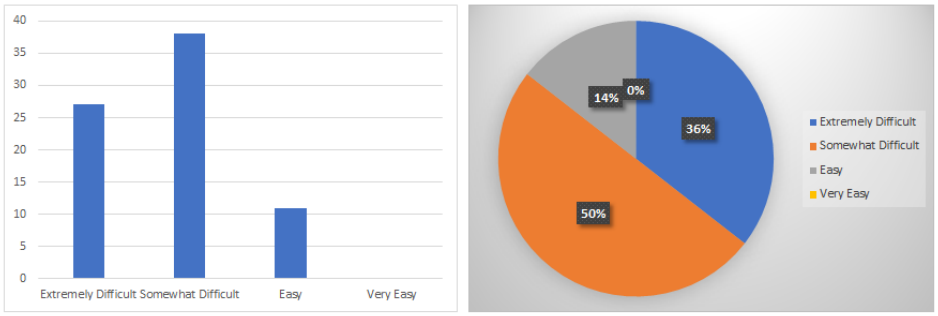

Figure 4.11: Level of difficulty to learn about Bugs and Debugging via this session

that the researcher's objective to include a learning factor with the help of female role models was clearly visible through the application. However, responses revealed that factors such as Engagement and Flow, Leaderboard, Personalization, and Collaboration were missing in the application.

One participant said: *"In terms of enjoyment, personally, I liked the way in which the story of female Computer Scientist was presented. This is because an inspiring story like that usually inspires the person reading it."*

Another participant said: *"While the application tries to focus on educational factor, for me, I think the application lacks the fun factor which is equally important to engage children. Likewise, the application acts like a prototype, and in the final build of the application, I would love to have multiple levels and difficulties, in terms of concepts that the application wants to teach to preteen kids."*

An open ended question was also asked in order to get suggestions from the

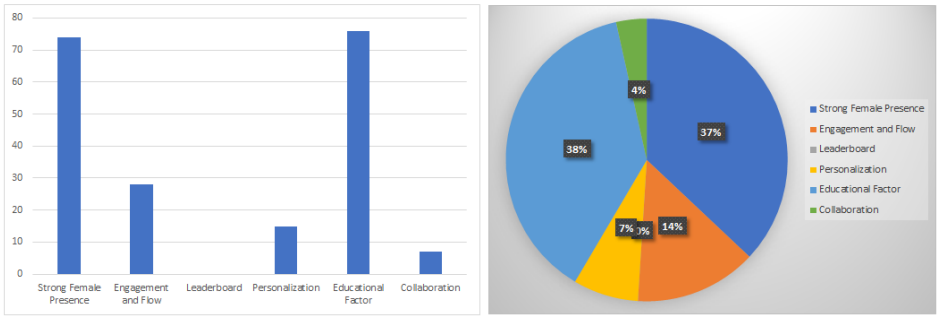

Figure 4.12: Design factors and gamification elements the participants found in the application

participants for further development of the application. Figure 4.13 shows that 43% participants suggested a multiplayer functionality in the application which introduces a feeling of collaboration among the users. Another 37% suggested design changes in order to make the application specifically built for children. This makes the application more appealing to the audience which is likely to increase them revisiting the application. 20% respondents also suggested depth of levels in the application to increase engagement and flow. With the completion of each level, the quiz tends to become more harder and thus increase the user's engagement in the application. Another frequently mentioned suggestion includes multi-platform inability which enables users to use the application via Android, iOS, PCs and laptops. Participants also reported lack of instructions in the application which made it difficult for them to navigate, and suggested in-app instructions after certain activity. The instructions can be shown at the beginning of each level or each activity. Leaderboard and sharing scores to friends were also suggested by participants, which creates a feeling of competition among peers. This competitive nature encourages the users to play more and learn more through the application. Finally, participants suggested sending out invites to friends to use the application which focuses of competition among players, engagement through multiplayer functionality, and increase in overall users of the application.

Lastly, when asked to rate the application from 1 to 5, one being the lowest and five the highest, 62% participants rated 3, 24% rated 2 and only 14% rated 4 (in Figure 4.14). This shows that the application needs more refinement and development in order to address the research problem to children in a way that they can understand it and be a part of it.

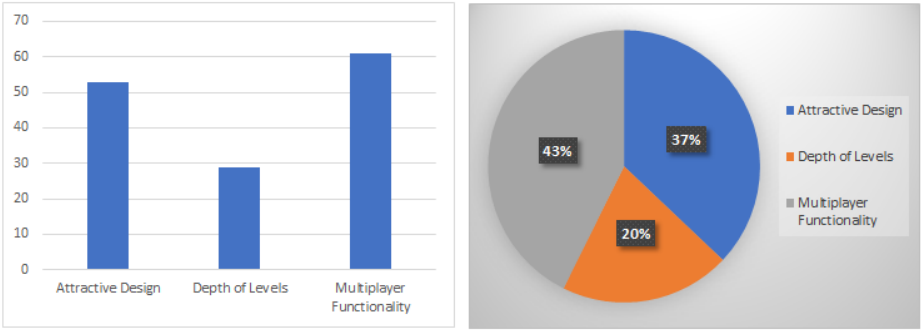

Figure 4.13: Suggestions for further development of the application

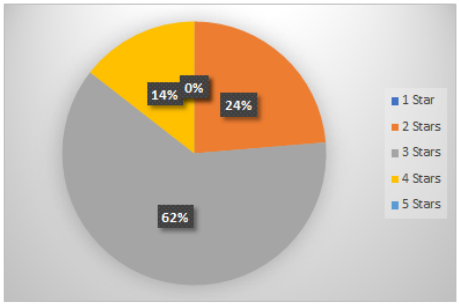

Figure 4.14: Participants' rating of the application

4.5.5 System Usability Scale (SUS) of the quiz application

The System Usability Scale (SUS) is an evaluation which assesses the usability of a system (Brooke (1995)). A questionnaire was used to determine the usability scale of the quiz application. The questionnaire used a Likert Scale, with a 5 point scale, in between the disagreement and agreement of an statement. Complete set of statements used in the SUS can be seen in detail in the **Appendix A** in Tables 6.1 and 6.2. The statements cover a variety of aspects related to system usability such as complexity of the application and the need for training and support. Therefore the usability test seems to have a high level of validity in measuring the usability of the application.

The usability scale was used after the participants completed using the quiz application and filled out their online surveys. Respondents were asked to check their answers in the SUS quickly as recommended by Brooke (1995), rather than thinking and taking long time to complete the scale. Instructions were given that all the statements were mandatory and if there were any occasion of confusion, the

candidate were to mark the centre point of the usability scale.

SUS Score	Grade	Adjective Rating
> 80.3	A	Excellent
68 – 80.3	B	Good
68	C	Okay
51 – 68	D	Poor
< 51	F	Awful

Figure 4.15: General guideline on SUS score interpretation (Source: Alathas (2018))

After analyzing the scores collected from the usability scale, the final SUS score was 75.4. The SUS score was calculated based on the guidelines presented by Brooke (1995) and Alathas (2018). Based on the score interpretation guideline as can be seen in Figure 4.15, the application seemed to have received warm response from the participants. However, many features are yet to be added in the application to make it better for the target audience.

Chapter 5

Discussion

In this chapter, we will discuss and analyze the research questions. The basis for the analysis is the data visualized and discussed in Chapter 4. We will also discuss possible future improvements which can make concrete impact on this research area, and make the application more directed towards the focus group.

5.1 Validation of Research

The first research question in this research stated **"What impact can educational applications have on girls perception of Computer Science?"** which addresses similar previous studies done in order to access the learning outcome, in Computer Science, of female participants via applications which are specifically designed with educational viewpoint. Chapter 2, Background, of this thesis report contributed in answering the research question. To evaluate the impact of educational applications on females, we merged our understanding of educational applications, the focus group, and the field of Computer Science. Various studies concluded on the positive note that educational applications and/or serious games can increase females' interest in Computer Science. Groover (2009), Spangenberger et al. (2018), Carmichael (2008), Akku akr et al. (2017), French and Crouse (2018), Webb et al. (2012), Lau et al. (2009), Jenson and Droumeva (2016), Robinson et al. (2015), AlHumoud et al. (2014) and Ouahbi et al. (2015) revealed participants' increased interest in Computer Science studies and also as a career option. Additional studies, Stewart-Gardiner et al. (2013), Bonner and Dorneich (2016), Adams (2010), Ioannidou et al. (2009) and Webb (2011), reported undetermined state which stated that participants could study Computer Science and/or pursue a career in Computing. Finally, some studies, Miller and Webb (2015), AlSulaiman

and Horn (2015), and Robertson (2013),reported no change or decrease in interest of the participants towards Computer Science. Most of these studies focused on young girls and used game design and gameplay, with an integration with learning intent, to make an impact on their philosophy regarding Computer Science.

The research answers the second research question, **"How can a educational application make an impact on preteen girls' interest in Computer Science careers?"**, by generating the concept of the application, designing and developing the application via a design and creation strategy presented by Oates (2006), and evaluating the application. The originality of the application's concept was inspired from several studies with similar research objective. For instance, Woit and Mason (2000) uses quizzes to make a positive change on students' learning in Computer Science courses. Schmitz et al. (2011) used a game to motivate learners to study information technology via game play activity. Sosnovsky et al. (2003) used a self-assessment QuizPack including parameterized questions, where the same question can be used over and over again with change in parameters so that any learner can acquire proficiency, which proved to be an extraordinary learning tool, especially to female students who usually lacked confidence in programming courses as opposed to male students. The design of the application was completely based on ideation and conceptualization in Section 3.1 which turned out to be feasible according to the research objective since the application focused mainly on the learning objective while adding dominating components like female presence and quiz. However, a detailed study on design of educational applications as presented in several studies such as Churchill (2009), Patten et al. (2006), Malone (1980) and Malone (1983) were lacking in this research. Among these studies, Patten et al. (2006) discusses the pedagogical aspects that should be studied and implemented in educational computer applications in order to appeal a certain focus age-group.

Identification of long term impact, regarding Computer Science careers, on the perception of preteen girls would be a rather difficult and time consuming research area, as tracking the focus group participants for several years would be a huge challenge. Additionally, this research, in particular, evaluates the application through students and/or professionals in Computer Science in order to get their understanding regarding the research and their feedback for further development of the application. The realization that a lot of resources and time in this thesis were spent on planning and developing the application from scratch, the researcher failed to run the application with the focus group (preteen girls aged 8 to 12), which creates a level of uncertainty on either the application will serve its purpose or not when it is run with the target group. Based on experts' feedback, this research project was turned into a preliminary conceptualized prototype on which future research would be based on, which would consist improved application or game which appeals the target audience. The result of this research project showcases

the potential of the concept as majority of participants provided positive feedback on the research objective and achievements of this project.

5.1.1 Threats to Validity

Empirical research are traditionally based on either quantitative or qualitative methods, however, today, a "mixed methods research" has been established in data collection, data analysis and interpretation (Creswell and Clark (2017)). Johnson et al. (2007) states the need for such an approach in order to obtain complete picture of the study and to improve the validity of theoretical implications. Ihantola and Kihn (2011) based their study on a classification by Ryan et al. (2002) where they concluded a variety of threats, such as internal/contextual and external validity, reliability, and generalizability and transferability, that ought to be examined in qualitative and quantitative research methods. Internal validity deals with whether the proposed solution can draw valid conclusions as aimed by the research. External validity deals with generalization and transfer the general conclusions on the basis of internal models used and data collected to a larger audience.

A major threat to both, internal and external validity of the research, is selection bias, first stated in Campbell and Gage (1963), which states the bias when selecting the participants in an experimental design. Likewise, in this research, the participants may have shared similar characteristics, such as their involvement in Computer Science, which might influence their understanding and thoughts towards this research project, and thus effect their result. Another important trait that can challenge internal validity of research is researcher bias, as defined by Onwuegbuzie (2003), where the researcher has a personal bias in favor of one technique over another, such as using PowerPoint for creating informative video as opposed to more advanced tools like Adobe After Effects. Researcher bias is also a result of the researcher's proficiency and expertise in certain technologies. Reactive arrangements, change in participants' responses after realizing their involvement in a research study, also threatens internal validity of the research as the participants are more likely to provide positive responses in research studies (Onwuegbuzie (2003)). This scenario has also been presented by Oates (2006).

According to Ryan et al. (2002), population, time and environmental validity are the three problems that might affect the external validity of a study. Population validity refers to the ability to draw inferences from the sample population, such as whether the results obtained through a sample population is valid for a larger population too. Howell (1995) states that a planned (not random) sample may not reflect the entire population which might result in meaninglessness in the research estimates. Time validity questions the generalization of a research study's result at a certain time to other time periods. An instance of time validity in this research

study is whether the research produces similar results when conducted with participants over long period of time, say, 1-2 hours of session. Finally, environmental validity refers to the generalization of results across different settings. An illustration of environmental validity in this research would be conducting the session with participants in class vs in a workshop.

5.1.2 Research Ethics

An important aspect in a research study is the ethics, which involves people and collecting and storing their personal information (Resnik (2007)). Ethically, the first step in this research was to make sure that participants were well-informed about the research, its context and objective. Participants were then provided a choice to volunteer in the experiment conducted in this research, as part of a Master's thesis. All the participants whose data has been used in this research participated voluntarily and no pressure was put for participation. When conducting an online evaluation of the thesis project, participants were provided information related to the project via email. The ambition and purpose of the thesis were described in detail so that the participants could get an abstract view of the research. Then, the personnel involved in the thesis were introduced, in this case, the researcher, the supervisor and the co-supervisors. The participants were detailed on why they were selected as the focus group of the study. In this case, the participants were told that they were selected because of their involvement in the field of Computer Science, either as students/learners or professionals. This was followed by a detailed introduction to different data collection methodologies and how to use them.

Another principal factor to be considered in the ethical side of a research is the ability to differentiate between personally identifiable traits. According to General Data Protection Regulation (GDPR), personal data are any information that can identify a natural person (GDPR (2018)). Attributes of a person such as full name, address, age, gender, phone number, and biometric data are personal data since they can be used to identify that person. In this research, participant's age, gender and nationality were recorded, but they were assured that their information would be presented in such a manner that any individual participant will not be identified from the published information. Also, the participants were informed that after the end of the thesis, their information will be anonymized. All this ethical processes were performed under guidelines of the Norwegian Centre for Research Data (NSD) who act as the official Data Protection agency for research studies in Norway. All the information can also be found in the application sent to the NSD for permission to conduct the research, as can be seen in **Appendix D** in Figures 6.1 and 6.2 respectively. The researcher received a template for the consent form

from the NSD which was modified according to the requirements of this research, and is attached to **Appendix E** in Figures 6.3, 6.4 and 6.5 in this thesis report.

5.2 Validation of Technology

The development of the application in React.js started with an idea to create single page application which would be easy to navigate, thus, removing the need for training the participants on how to use the application. However, the researcher's lack of proficiency in the platform seemed to be a challenge in order to complete a fully functional application in time. This challenge proved to be fatal since some functionalities that were planned at the ideation phase could not be implemented. Another choice of technology which was later criticised by the researcher was the Heroku platform for hosting the application online. While this worked fine, the runtime increased in the later phase of testing. The participant had to wait for some time for the application to load. Even though the time ranged from 10-15 seconds to around 45 seconds, this seemed to create a level of inconsistency and was also considered a factor that interrupted flow.

5.3 Future development of the application

Based on the responses from the participants, the application was considered viable for further development. The participants provided positive reviews to the application and reported that educational applications as such can be used in learning. Additionally, participants stated that preteen females can easily learn Computer Science concepts through media integrated educational applications. However, the application is not complete and can be modified in both, design and functionality, as per the researcher's own ideas and also from feedback received while evaluating the application.

Firstly, one main issue raised by the participants regarding the application is its lack of in-app instructions. Therefore, adding instructions in various location in the application can make navigation simpler and effortless. Secondly, the user interface of the application can be made more appealing and attractive with visually pleasing interface. The user interface is the first look of any application and a better looking interface attracts the user to explore the application. The interface should be more appealing to preteen girls to avoid them from not using the application at all. Inclusion of factors young females like, such as stories and puzzles, can be included in the application.

Addition of gamification elements into the application to modify it into a serious game can be a good update to this application. This includes inclusion of

game design factors such as personalization of the user avatar, user engagement and flow, learning, leaderboard, offline capability, and depth of the application. Among these, personalization is one of the most important since it can enable participants to create a picturesque copy of themselves or someone they admire. Modification of the application into a game can attract more players and, eventually, the game might impact more young minds in future. Also, research studies shows that young children are more interested in games as opposed to educational applications.

Finally, in order to achieve the potential of the application presented in this research study, the application has to undergo many changes. Incorporation of game design factors in the application, modifying the application into a game, may be better suited to positively impact preteen girls' perception of Computing careers.

Chapter 6

Conclusion

The thesis aimed to develop and evaluate an application that can make a positive impact on preteen girls' interest towards Computing careers. The context for this thesis originated from the Project Tappetina Ecosystem (https://tappetina.com/) which focuses on increasing the involvement of women in Computer Science. In order to meet the objective of this research, an initially formulated alternative was to use serious games to inform young girls about the prospects of careers in Computer Science. This meant familiarizing young girls with facts and figures in the Computer Science industry and trying to get them interested in Computer Science on its basis. This was later changed to accommodate the feeling of accomplishment alongside learning through the application. Finally, with a thorough discuss with co-supervisor Kshitij Sharma, the decision was made to develop a quiz application, with a hint of exposure to female role models in the field of Computer Science, which could enable learning basic Computer Science concepts. Rather than examining and determining the impact of the project on preteen girls, the project aims to determine the feasibility and potential for an education application to accomplish the goal of this research. This results in a clear understanding of the application and its necessary components that are required to make an impact on preteen girls' interest in Computer Science careers. While the results obtained through this research are not rigorous and there is no guarantee that another study in similar settings can produce equivalent results, participants in this study revealed the possibilities the application can achieve in future in this research domain. As an overview of the thesis as a research project, let us look at the research questions and how they were answered.

The first research question *"What impact can educational applications have on girls perception of Computer Science?"* tries to explore existing studies performed to access the effect of using educational applications with relation to girls' interest

in Computer Science. Relevant literature and related works, in Chapter 2, contributed to answer this question. Instead of diving directly to effect of educational applications on girls, the Background of this thesis report consists, firstly, of how women are represented in Computer Science, which is then followed by strategies previously employed to increase female participation in Computer Science. This revealed the importance of increase in female participation in both, Computer Science education and careers. Later in the Background, an introduction to educational applications and its impact on learning is presented. Through this, an outline of major elements, such as engagement, flow, fun and learn, that are required for developing an application that can address the goal of this research is perceived. Finally, the use of serious games in learning and its evolution throughout the years is introduced. This provides an insight into development of the application into serious games with a long-term plan. The chapter also took note of design elements considering serious games, and how the use of serious games has already yielded positive results in this research domain.

The second research question *"How can a educational application make an impact on preteen girls' interest in Computer Science careers? "* attempts to evaluate the impact, either positive or negative, made on preteen girls' interest towards Computer Science careers via research strategies discussed in Section 4.1 of Chapter 4. The main contributions to answer this research question was made through design and creation process which was followed by an evaluation of an experiment. While the research methodology implemented in this research project is not rigorous enough to provide concrete and decisive answer to this question, the evaluation of the project provides enough evidence as the basis for further research. A brief preview of the effects of using educational application for learning and increasing female participation in Computing careers has already been observed through this research.

Finally, as a summary, we would like to highlight that the Masters thesis can be considered a success but not without its limitations. Even though the context of the design was open, it was difficult to determine a concept that could cover the scope of this research. The decision to design and develop an educational quiz application came with its own challenges and weaknesses. Additionally, it was tough to determine the periphery of the literature surrounding the research, and design elements that could be integrated into the application. Albeit all these circumstances, the application showed real potential, thus, paving a path for further development and future research.

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Appendix

Appendix A presents the statements used System Usability Scale, and the responses provided by the 23 participants in Table 6.1 and 6.2 respectively.

Table 6.1: Statements used in System Usability Scale

Q1	I think I would like to use the application frequently.
Q2	I found the application unnecessarily complex.
Q3	I thought the application was easy to use.
Q4	I think that I would need the support of a technical person to be able to use this application.
Q5	I found the various functions in this application were well integrated.
Q6	I found the application very cumbersome to use.
Q7	I would imagine that most people would learn to use this application very quickly.
Q8	I needed to learn a lot of things before I could get going with this application.
Q9	I felt very confident using the application.
Q10	I thought there was too much inconsistency in this application.

Table 6.2: Participants and their responses in System Usability Scale

P/Q	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
P1	3	1	4	1	2	2	4	1	3	3
P2	2	1	5	1	3	1	5	1	3	2
P3	4	2	4	1	3	1	5	1	4	3
P4	3	1	4	1	2	1	5	1	4	2
P5	3	1	4	1	3	1	4	1	2	2
P6	2	1	4	1	3	1	4	1	2	2
P7	2	1	4	1	2	1	4	1	3	2
P8	4	1	5	1	2	1	4	2	4	1
P9	2	2	5	1	2	1	4	1	3	1
P10	3	1	5	1	2	2	4	1	3	1
P11	1	2	3	2	2	2	5	2	3	3
P12	4	1	4	1	2	1	5	1	3	2
P13	4	1	4	1	2	1	5	1	3	2
P14	4	1	4	1	2	3	5	1	3	2
P15	3	1	4	1	2	1	3	1	3	3
P16	2	1	4	1	1	3	5	1	2	3
P17	3	1	3	2	1	1	5	1	4	2
P18	3	2	5	1	3	1	5	2	2	2
P19	4	2	3	2	3	1	4	1	3	2
P20	4	1	5	1	3	1	4	1	3	1
P21	1	1	5	1	3	1	4	1	4	3
P22	3	1	5	1	2	1	5	1	4	2
P23	4	1	4	1	3	1	4	1	3	1

Appendix B contains the questionnaire survey used in the research as a data collection method which is present in Table 6.3.

Table 6.3: Questions used in Survey questionnaire for data collection

Q1	What is your age?
Q2	What is your gender?
Q3	What is your nationality?
Q4	Are you currently involved in some area of Computer Science?
Q5	Having female role models to project career situations is critical to opening doors for girls to consider career in computer science.
Q6	Would you mentor and/or encourage young girls to enter a computer science or information technology fields?
Q7	Sessions like this will influence young girls' decision to choose a career in some area of computer science or information technology.
Q8	Sessions like this will help preteen girls learn basic Computer Programming concepts.
Q9	How difficult will it be to learn basic concepts of Loops via this session?
Q10	How difficult will it be to learn about Programming Bugs and Debugging via this session?
Q11	Which design factors did you find in the application?
Q12	What changes would you suggest in the further development of the application?
Q13	Overall, how would you rate this application?

Appendix C contains the list of interview questions asked to individual participants, in order to achieve detailed understanding of the project, as a data collection method which is present in Table 6.4.

Table 6.4: Structured Interview Questions used for data collection

Q1	Did you like the session?
Q2	Do you think sessions like this could encourage female towards Computer Science careers? Why?
Q3	Do you think games like this could increase preteen girls knowledge? Why?
Q4	What was the aspect you enjoyed the most in the game?
Q5	Do you have any suggestions to further develop the game?

Appendix D contains the assessed application from the NSD which states that the researcher can now carry out the research.

NSD NORSK SENTER FOR FORSKNINGSDATA

NSD's assessment

Project title

Games and Girls' Perception of Computer Science Careers

Reference number

769600

Registered

09.04.2019 av Kshitiz Adhikari - kshitiza@stud.ntnu.no

Data controller (institution responsible for the project)

NTNU Norges teknisk-naturvitenskapelige universitet / Fakultet for informasjonsteknologi og elektroteknikk (IE) / Institutt for datateknologi og informatikk

Project leader (academic employee/supervisor or PhD candidate)

Kshitij Sharma, kshitij.sharma@ntnu.no, tlf: 41209147

Type of project

Student project, Master's thesis

Contact information, student

Kshitiz Adhikari, kshitiza@ntnu.no, tlf: 96707435

Project period

07.01.2019 - 11.06.2019

Status

10.05.2019 - Assessed

Assessment (1)

10.05.2019 - Assessed

Our assessment is that the processing of personal data in this project will comply with data protection legislation, so long as it is carried out in accordance with what is documented in the Notification Form and attachments, dated 10.05.2019, as well as in correspondence with NSD. Everything is in place for the processing to begin.

NOTIFY CHANGES

Figure 6.1: NSD application (Page 1)

If you intend to make changes to the processing of personal data in this project it may be necessary to notify NSD. This is done by updating the information registered in the Notification Form. On our website we explain which changes must be notified. Wait until you receive an answer from us before you carry out the changes.

TYPE OF DATA AND DURATION
The project will be processing general categories of personal data until 11.06.2019.

LEGAL BASIS
The project will gain consent from data subjects to process their personal data. We find that consent will meet the necessary requirements under art. 4 (11) and 7, in that it will be a freely given, specific, informed and unambiguous statement or action, which will be documented and can be withdrawn. The legal basis for processing personal data is therefore consent given by the data subject, cf. the General Data Protection Regulation art. 6.1 a).

PRINCIPLES RELATING TO PROCESSING PERSONAL DATA
NSD finds that the planned processing of personal data will be in accordance with the principles under the General Data Protection Regulation regarding:

- lawfulness, fairness and transparency (art. 5.1 a), in that data subjects will receive sufficient information about the processing and will give their consent
- purpose limitation (art. 5.1 b), in that personal data will be collected for specified, explicit and legitimate purposes, and will not be processed for new, incompatible purposes
- data minimisation (art. 5.1 c), in that only personal data which are adequate, relevant and necessary for the purpose of the project will be processed
- storage limitation (art. 5.1 e), in that personal data will not be stored for longer than is necessary to fulfil the project's purpose

THE RIGHTS OF DATA SUBJECTS
Data subjects will have the following rights in this project: transparency (art. 12), information (art. 13), access (art. 15), rectification (art. 16), erasure (art. 17), restriction of processing (art. 18), notification (art. 19), data portability (art. 20). These rights apply so long as the data subject can be identified in the collected data.

NSD finds that the information that will be given to data subjects about the processing of their personal data will meet the legal requirements for form and content, cf. art. 12.1 and art. 13.

We remind you that if a data subject contacts you about their rights, the data controller has a duty to reply within a month.

FOLLOW YOUR INSTITUTION'S GUIDELINES
NSD presupposes that the project will meet the requirements of accuracy (art. 5.1 d), integrity and confidentiality (art. 5.1 f) and security (art. 32) when processing personal data.

NSD presupposes that the processing of personal data by a data processor meets the requirements under the General Data Protection Regulation arts. 28 and 29.

To ensure that these requirements are met you must follow your institution's internal guidelines and/or consult with your institution (i.e. the institution responsible for the project).

FOLLOW-UP OF THE PROJECT
NSD will follow up the progress of the project at the planned end date in order to determine whether the processing of personal data has been concluded.

Good luck with the project!

Figure 6.2: NSD application (Page 2)

Appendix E presents the consent form which was sent to each participant who were involved in the research study. Participants had to sign the consent form and send it back to the researcher before using the application and sharing their data with the researcher.

Are you interested in taking part in the research project

***"Games and Girls' Perception of Computer Science Careers"*?**

This is an inquiry about participation in a research project where the main purpose is to access participants' interest in Computer Science careers via gameplay using a serious game. In this letter we will give you information about the purpose of the project and what your participation will involve.

Purpose of the project
The project aims to access preteen girls' perception of Computer Science careers through a gameplay activity. An educational application is built for this purpose, which incorporates video and quiz elements to expose participants to basic Computer Science concepts and their respective pioneering computer scientists. Female Computer Scientists are focused in the project to better represent the female participants.

The main objective of the project is to access the impact of the session (via an educational app) on participants' perception about Computer Science and its careers. Additionally, the project aims to inspire preteen girls towards taking a Computer Science career in future as women in Computer Science are underrepresented.

This is a research project conducted as a Master's thesis for NTNU.

Who is responsible for the research project?
Norwegian University of Science and Technology (NTNU) is the institution responsible for the project.

Additional personnel involved in this project are:
- Kshitiz Adhikari, Student
- Kshitij Sharma, IDI – Co-supervisor
- Javier Gomez Escribano, IDI – Co-supervisor
- Professor Letizia Jaccheri, IDI – Supervisor

Why are you being asked to participate?
The sample population are selected based on their expertise in the field of Computer Science. All the participants are students or PhDs or Postdoktor. You are asked to participate in order to provide your views on the project's objectives and its achievability through the educational quiz-application.

While we do not have a fixed size for the population of the focus group, we have fixated the idea on total participants of 50 to 100.

What does participation involve for you?
Following methods will be used to collect information:
- Online survey: Participants are required to fill out post survey after the session.
- Interview: Few candidates are random will be asked to volunteer for interview regarding the session and the interviewer will take notes during the interview.

If you choose to take part in the project, this will involve that you participate in the online survey. This will take approximately 15 minutes. The survey includes questions about the participants'

Figure 6.3: Consent Form for the participants (Page 1)

summarization on the application and its applicability in the project objectives. Your answers will be recorded electronically.

Additionally, you might also participate in the interview. This will take approximately 5-8 minutes. The interviewer will ask questions related to the session (which features were fun), features lacking in the game, and future enhancements for the game.

Participation is voluntary
Participation in the project is voluntary. If you chose to participate, you can withdraw your consent at any time without giving a reason. All information about you will then be made anonymous. There will be no negative consequences for you if you chose not to participate or later decide to withdraw.

Your personal privacy – how we will store and use your personal data
We will only use your personal data for the purpose(s) specified in this information letter. We will process your personal data confidentially and in accordance with data protection legislation (the General Data Protection Regulation and Personal Data Act).

The personal information of the participants will be accessible by following institution or individuals:

- Norwegian University of Science and Technology (NTNU)
- Kshitiz Adhikari, Student, MSc in Information Systems at NTNU
- Kshitij Sharma, IDI, Postdoktor
- Javier Gomez Escribano, IDI, Postdoktor
- Letizia Jaccheri, IDI, Professor at NTNU

If the project details are shared with other personnel, as opposed to the ones listed above, we will remove the name and other contact details and replace it with a code. The names and other personal data that can reveal the identity of the participants will be stored separately from the rest of the collected data. The data will be locked away and will not be accessible to other personnel expect for the ones involved in this project and listed above.

The data collected through surveys will be subject to analysis for this project only. After the end of the project, the data will be anonymized.

The participants will not be recognizable via the data published in the report of this thesis. This is because we will publish generalized age, gender and nationalities of the participants.

What will happen to your personal data at the end of the research project?
The project is scheduled to end on June 2019. After the project ends, the data will be locked away in storage. This is because the researchers believe that the data can be useful for future research, if any. The personal data will likely be stored in Dropbox and only the author of this thesis will have access to it. Since only the generalised data will be of use to further research, all personally identifiable information will be removed after the project has ended. The date for anonymisation is predicted to be the end of July 2019.

Your rights
So long as you can be identified in the collected data, you have the right to:

- access the personal data that is being processed about you
- request that your personal data is deleted
- request that incorrect personal data about you is corrected/rectified
- receive a copy of your personal data (data portability), and

Figure 6.4: Consent Form for the participants (Page 2)

- send a complaint to the Data Protection Officer or The Norwegian Data Protection Authority regarding the processing of your personal data

What gives us the right to process your personal data?
We will process your personal data based on your consent.

Based on an agreement with Norwegian University of Science and Technology (NTNU), NSD – The Norwegian Centre for Research Data AS has assessed that the processing of personal data in this project is in accordance with data protection legislation.

Where can I find out more?
If you have questions about the project, or want to exercise your rights, contact:

- Norwegian University of Science and Technology (NTNU) via Professor Letizia Jaccheri, IDI, +47 73 59 34 69.
- Our Data Protection Officer: Kshitiz Adhikari, Student, +47 96 70 74 35.
- NSD – The Norwegian Centre for Research Data AS, by email: (personverntjenester@nsd.no) or by telephone: +47 55 58 21 17.

Yours sincerely,

Project Leader (Researcher/supervisor)

Student (if applicable)

Consent form

I have received and understood information about the project "Games and Girls' Perception of Computer Science Careers" and have been given the opportunity to ask questions. I give consent:

- ☐ to participate in an interview
- ☐ to participate in an online survey

(Signed by participant, date)

Figure 6.5: Consent Form for the participants (Page 3)