VOCABULARY BUILDER MODEL FOR AUTISTIC CHILDREN

MARYAM RASTIKAZEROONI

FACULTY OF COMPUTER SCIENCE AND INFORMATION TECHNOLOGY
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MARYAM RASTIKAZEROONI

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VOCABULARY BUILDER MODEL FOR AUTISTIC CHILDREN

ABSTRACT

Most children with autism suffer from impairments in specific cognitive processing styles, social skills, and communication skills, which affect the academic performance of those children in pre-school. The difficulties in language comprehension and communication skills result in the lack of motivation, attention, satisfaction, and interaction in this population, thus causing the children to encounter deficits in learning and especially learning vocabulary. Many Mobile-Based interventions (MBI) have been developed to address the deficits in this population. However, there are very few vocabulary builders' software which focus on improving the vocabulary learning skills as well as providing consistent motivation for autistic children. Therefore, the aim of this study is to develop a new Mobile-Based Intervention Vocabulary Learning Model using the Picture Exchange Communication System (PECS) and Digital Storytelling (DS) together to help children with autism in acquiring English vocabulary learning skills. In this study, the design science research method (DSRM) was used which is a 6-step method for developing and evaluating the prototype. This study developed an MBI English vocabulary learning model, implemented as a prototype Mobile-based system and the system was conducted to evaluate the performance of children and usability of the prototype by 10 autistic pre-school-aged students. The evaluation results show that the software prototype is very useful, effective, and of a usable performance to help in addressing the vocabulary learning deficits in this group of kids. The autistic students showed significant improvement in terms of word learning performance and retention after using the MBI English Vocabulary learning for 3 weeks (15 sessions). More comprehensive models for learning vocabulary comprehension with sentence construction are considered for future work.

Keywords: Mobile-Based Intervention, Performance, DS, PECS, Autistic children

MODEL BUILDER VOCABULARY BERBASIS GAME UNTUK ANAK AUTISTIK

ABSTRAK

Sebilangan besar kanak-kanak dengan autisme mengalami gangguan dalam gaya pemprosesan kognitif tertentu, kemahiran sosial, dan kemahiran komunikasi, yang mempengaruhi prestasi akademik kanak-kanak tersebut di prasekolah. Kesukaran dalam pemahaman bahasa dan kemahiran komunikasi menyebabkan penurunan motivasi, perhatian, kepuasan, dan interaksi dalam populasi ini dan perkara ini menyebabkan prestasi pembelajaran yang rendah, terutamanya dalam mempelajari perbendaharaan kata. Banyak intervensi Berasaskan Mudah Alih (MBI) telah dikembangkan untuk mengatasi kelemahan tersebut dalam populasi ini. Walaubagaimanapun, terdapat sedikit perisian pembangun perbendaharaan kata yang menumpukan peningkatan dalam kemahiran menguasai perbendaharaan kata di samping memberi dorongan yang konsisten bagi kanak-kanak autistik. Oleh itu, tujuan kajian ini adalah untuk membangunkan Model Pembelajaran Perbendaharaan Kata Intervensi yang Berasaskan Bergerak dengan menggunakan PECS dan DS untuk membantu kanak-kanak autistic untuk memperoleh kemahiran menguasai perbendaharaan kata Bahasa Inggeris. Dalam kajian ini, kaedah penyelidikan sains reka bentuk (DSRM) digunakan iaitu kaedah 6 langkah untuk mengembangkan dan menilai prototaip. Kajian ini membangunkan model pembelajaran kosa kata bahasa Inggeris MBI, yang dilaksanakan sebagai sistem berasaskan mudahalih prototaip dan sistem ini dijalankan untuk menilai prestasi kanak-kanak dan kebolehgunaan prototaip oleh 10 pelajar pra-sekolah autistik. Hasil penilaian menunjukkan bahawa prototaip perisian adalah sangat bermanfaat, berkesan, dan dapat digunakan untuk membantu menangani kelemahan dalam penguasaan perbendaharaan kata dalam golongan kanak-kanak ini. Pelajar autistik menunjukkan peningkatan yang signifikan dari segi prestasi dan pengekalan pembelajaran kosa kata setelah menggunakan

pembelajaran Perbendaharaan Kata Bahasa Inggeris MBI selama 3 minggu (15 sesi). Model yang lebih komprehensif untuk belajar pemahaman kosa kata dengan pembinaan ayat akan dipertimbangkan dalam penyelidikan seterusnya pada masa hadapan.

Kata kunci: Intervensi Berasaskan Mudah Alih, Prestasi, DS, PECS, kanak-kanak Autistik

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

ADDM	:	Autism & Developmental Disabilities Monitoring
ASD	:	Autism Spectrum Disorder
CBI	:	Computer-Based Interventions
CDC	:	Centers for Disease Control
DS	:	Digital Storytelling
DSRM	:	Design Science Research Method
GBVB	:	Game-Based Vocabulary Builder
MB-VBM	:	Mobile-Based Vocabulary Building Model
MGB	:	Mobile Game-Based
NASOM	:	National Autism Society of Malaysia
PECS	:	Picture Exchange Communication System
SLR		Systematic Literature Review
UI	:	User Interface
W3C	:	World Wide Web Consortium

LIST OF APPENDICES

CHAPTER 1: INTRODUCTION

This chapter starts with the background of the research and presents the motivation for conducting this research. The problem statement, statement of purpose, research questions, and research objectives are also presented. The scope, significance, and limitations of the research are described. Finally, it presents the structure of the thesis.

1.1 Research Background

Autism Spectrum Disorder (ASD) is a developmental neurological disorder. It is referred to as a spectrum based on either its disability or impairment levels, alongside its wide range of symptoms. Thus, factors characterizing autism includes: social communication impairment as well as behaviours prone to restriction or repetition. Consequently, symptoms of autism usually appear within the first 3 years of a child's life, which later affects the rest of their life. Imperatively, differences exists among autism affected children, with regards to how being very verbal, non-verbal, as well as those who are challenged intellectually (Walker & Carta, 2019). No single cause for ASD is known so far, but some behaviours are known to be associated with ASD which are: difficulties in executive functioning, poor interests, poor planning and reasoning skills, delay in learning of language, weak skills in motors, deficits in eye contact, difficulties in holding a conversation, narrow and sensual sensitivities. Hence, individuals with ASD may have many of these symptoms or just some of them, or even some more besides the aforementioned (Jenkinson, Milne, & Thompson, 2020).

In the Autism & Developmental Disabilities Monitoring (ADDM) autism prevalence report of the Centre for Disease Control and Prevention in 2018, it is shown that the prevalence of Autism had a rise of 1 in every 59 children in the US. Previously, in 2004, this rate was 1 in 125, and in 2009, it was 1 in 110 children (Nally, Healy, Holloway, & Lydon, 2018). However, it has been revealed from research, that most parents actually

take their kids for language development delay evaluation at a very early stage of the child's life. Thus, language acquisition among autism affected children is characterised by dramatic delays, implying that when the child is averagely 38 months old, it is possible for them to speak, as compared to typically developing (TP) children who can speak averagely at 8-14 months old (Fan, Antle, & Warren, 2020).

Comprehension in reading comprises two vital and distinctive components (Duff & Clarke, 2011). These components include, Decoding and Language Comprehension, hence the ability of a child in decoding a text as well as understanding it, ensures the readability of that child (Khowaja & Salim, 2013). As informed by some researchers (Khowaja, Salim, & Asemi, 2019), reading comprehension is among the most vital academic skills learnt by students in school. Though, autism affected children possess very good skills for decoding, which refers to being able to translate speech from text, a part of reading comprehension, however, there is a limit among the children regarding their skills of language comprehension – the ability of understanding spoken language, which of course is a very important component in reading comprehension.

Furthermore, one of the major as well as basic language component is the meaning of specific words, or vocabulary, also known as lexicon. This constitutes a group of words providing a foundation for any language formation. Thus, children begin to learn as well as develop their vocabulary at the infant stages, this proceeds even at the toddler stage, for example when they listen to an individual speak, until they eventually begin speaking properly. An individual's vocabulary evolves continuously as they begin to read diverse materials, as well as participate in communication with other individuals. Thus, there is a direct impact on reading comprehension from the learning vocabulary (Al-khresheh, 2020). To achieve proper understanding of a read text, it is imperative to have knowledge

of around 95% of words in a particular text (Khowaja et al., 2019). The aforementioned gives an indication that world level processing is a vital aspect of a comprehension.

Typically, ASD affected children need a personal instruction based learning. Thus, Mobile-based intervention (MBI), a type of intervention used extensively among the education sector, has been suggested to be used as a tool in supporting teachers of ASD inclined children (Sofian, Hashim, & Ahmad, 2018). A vocabulary builder design comprises diverse constituents, which are integrated as one on a core structure, which results in communication among the parties, as well as ensures provision of a basic foundation for the design of a learning environment for learning (Mohammad, Abu-amara, & Dhabi, 2019). Consequently, the components alongside the prototype structure plays an important role in designing the vocabulary learning, with the aim of catering for the user's needs. The components provides guidance on the necessary items to be incorporated, whereas the structure sets guidelines for the manner of incorporating the design components (Moore & Calvert, 2014). Some of the symptoms seen in autistic children are classified in Table 1.1.

Table 1.1: Symptoms of ASD (Brentani et al., 2013; Bosseler & Massaro, 2003; Johnson, 2004)

No	Category	Symptoms
1	Social skills	o They cannot talk, play, or relate to people o When people talk to them, they don't pay attention
2	Communication	o They are afraid of relating to others o They avoid eye contact o They want to be alone
3	Behavior	o They do a lot of repetitive movements o They prefer doing a familiar routine o Unusual sensory interests o They repeat an action recurrently
4	Learning the language	o Delayed speech development o Not able to speak at 37 months of age o Frequently repeating set words and phrases o Speech that sounds very monotonous or flat o They prefer to communicate using single words
5	Sensory & Play	o Some kids are shy o They do not play "pretend" games o They do not point at objects to show interest o They have unusual reactions to the senses such as smell, taste, look, feel, or sound

1.2 Research Motivation

Recent research on the learning ability of autistic children shows that learning among autistic kids requires continuous intervention and support in educational contexts. Scholars have also pointed out that teachers may face challenges with learning abilities in their students with autism, indicating that more serious learning instructions are needed for autistic students to avoid the dangers of learning deficits in these children (Nally et al., 2018).

Furthermore, research has shown that autism-inclined children feel more comfortable using mobile technology. It has also been revealed that integrating a mobile device with learning and teaching can help autistic kids learn better than the traditional way with the

teacher. The benefits of using mobile-based technology interventions for learning vocabulary compared to a human teacher can be mentioned as being accessible, portable, practicing any time (Moore & Calvert, 2014; Sung, Chang, & Liu, 2015). However, there is a lack of studies that have carried out investigations on the use of MBI for vocabulary learning among these children.

Crespo and Martin (2018) informed that children tend to be more attentive when using a PECS system as compared to using a traditional PECS communication book in classroom; they prefer using PECS system to learn vocabulary. This implies that the PECS system tends to be of great use for these children in learning vocabulary. However, to achieve the aforementioned, there is a need for investigations as regarding the process of developing a PECS system that can boost practicing, learning and improvement of vocabulary for the children (Crespo & Martin, 2018).

Also, the use of storytelling methods is an exciting approach for engaging kids in verbal communication and listening. Storytelling is a powerful method as it can be used in enhancing learning of vocabulary among autistic kids. Based on the reliance of storytelling on words, it thence offers a great language experience for ASD inclined children. Furthermore, promotion of language development can be achieved via assimilating stories as well as understanding the language patterns and vocabulary of the stories (Schwartz & Beck, 2020). Hearing stories improves many language skills, including vocabulary learning, as well as listening and verbal speaking skills (Rahimi & Yadollahi, 2017).

In this section, three issues comprising MBI development utilization on how to learn vocabulary, the usefulness of PECS & DS (Digital Storytelling) and components for vocabulary builder design framework have been highlighted. Thus, this research is aimed at a framework construction targeted at being used for designing a Mobile-Based

Vocabulary Builder, that helps autistic children learn new words, improve their vocabulary, and develop language in an easy way!

1.3 Problem Statement

In this section, related research problems to vocabulary learning by autism inclined children, alongside the use of mobile-based interventions, are being discussed. Brewer and Hunter (2006) in their work, informed that concerns as well as issues observed by researchers could be seen as gaps in the research. Thus, for this work, gaps are referred to as research problems. The gaps as discussed further for this research, stands as the motivating drive for conducting this research (Brewer & Hunter, 2006).

Most of the Autistic students do not receive sufficient instructions for learning vocabulary during childhood. Therefore, they have deficits in reading performances (Nally et al., 2018; Kravits, Kamps, Kemmerer, & Potucek, 2002). Besides, most of the teachers who are responsible for delivering vocabulary builder instructions to the autistic children are not sufficiently skilled to teach vocabulary effectively (Spector & Cavanaugh, 2015). According to Nally et al. (2018), reading abilities in children with ASD is below the average rate and these children still need better and interactive learning instructions to build their vocabulary proficiently (Nally et al., 2018). Some studies suggest that lack of motivation and confidence, due to the effects of limited instruction, failure at school tasks and poor skills also affect vocabulary building and reading skills (Ventura & John, 2009; Bosseler & Massaro, 2003). These deficits cause them not just to delay in learning but also reduces their quality of life in society. By fulfilling these deficits, Autistic children will be able to learn vocabulary better (Fan et al., 2020).

Difficulties in phonological processing of Autistic children have been noticed by researchers (Nally et al., 2018; Spector & Cavanaugh, 2015). Also, whole-word reading is a relative strength in these children (Luyster & Lord, 2011). Some studies suggest that

using healthy food words for vocabulary building can help Autistic children in learning whole-word reading which will help them in better learning (Curtin et al., 2016; Cermak, Bandini, & Curtin, 2013).

Mobile-Based interventions are needed for early learning to address the barriers that children with ASD face when receiving vocabulary builder instructions (Mohammad et al., 2019). The importance of vocabulary builders with regards to improving comprehensible reading has been acknowledged by practitioners and researchers (Eutsler, Mitchell, Stamm, & Kogut, 2020). Also, review studies specifically written on mobile applications for Autism Spectrum Disorder (ASD) children, with the aim of finding out how this significantly influences the children have been conducted (Mkpojiogu, Hussain, & Hassan, 2018; Novack, Hong, & Dixon, 2019). The researchers analysed diverse mobile application types, available for ASD inclined children. The results from this analysis show that MBI has been used extensively in providing extra skills that are associated with ASD incline children, however there are fewer studies and applications on MBI to support ASD inclined preschool children in learning vocabulary (Xanthopoulou, Kokkalia, & Drigas, 2019; Crespo & Martin, 2018; Eutsler et al., 2020; Mkpojiogu et al., 2018).

In a research that focused on a framework of education vocabulary builder, designed for ASD inclined children, it was discovered that a lot of challenges are being posed by the design of education software for autism-inclined children. A few recommendation guidelines as well as methodological procedures regarding technology design for ASD inclined children exist in literature (Luyster & Lord, 2011). However, just a few general guidelines sources was discovered at the aforementioned stage, which were limited in relevance. An instance is the provision of 28 “teaching tips for autism-inclined children” (Grandin, 2002) of which some have some relevance in ICT, such as sudden sound

loudness avoidance, where there is better performance in some, when there is a close proximity between the screen and the keyboard (Grandin, 2002). Most of the existing studies design educational vocabulary builder with limited aspects and simple steps. Limitations exist with regards to vocabulary builder software that is designed exceptionally for autism-inclined children (Luyster & Lord, 2011; Joseph, Skwerer, Eggleston, Meyer, & Tager-flusberg, 2019). Therefore, a vocabulary builder design framework or model for autistic children is unavailable (Millen, Cobb, & Edlin-White, 2010).

1.4 Research Questions

The main research question for this study is:

How to improve learning skills in children with autism using educational methods Mobile-Based Interventions to learn English words easily?

The above main Research Question includes the following sub-questions:

1. How effective are the Mobile-Based learning interventions for helping children with autism?
2. What are the current learning interventions for improving vocabulary learning skills in autistic children?
3. Which educational methods have been used in the existent vocabulary learning interventions?
4. Which vocabulary learning interventions and design strategies are suggested for better learning of children with autism?
5. How to use educational methods in the Mobile-Based Interventions to help children with autism for better vocabulary learning purposes?

6. How to ensure the effectiveness of the Mobile-Based Interventions for autistic children?

1.5 Research Objectives

To answer the questions mentioned above and to achieve the purpose of the current research, four objectives have been identified and are given thus:

1. To identify strategies and methods of vocabulary instruction for autistic children on the current Mobile-Based vocabulary interventions research.
2. To develop a Mobile-Based model for English vocabulary building using appropriate vocabulary building instructions development for autistic kids.
3. To develop a prototype of the model.
4. To evaluate the effectiveness and performance of the developed prototype.

1.6 Scope of the Research

This study is scoped at the proposal of a new process model for designing a vocabulary builder via interactive mobile technologies. The focus of this study is to learn new words, improve English Vocabulary, and develop language learning skills using interactive mobile technologies. In this study, the research focuses on fulfilling the needs of autistic kids in attention, motivation, verbal proficiency, listening skills, and interaction. This research used children with autism, those within the age range of 5 and 6 years old, to experimentally evaluate the developed prototype through the proposed model of this study. Specifically, the children used in the experiment hail from Shiraz, an area in Iran.

1.7 Significance of the Research

Contemporarily, numerous studies have been conducted with regards to the design and development of vocabulary learning. However, not a single study to the best knowledge of the researcher, has been carried out which discussed the mobile-based English

vocabulary builder design model for pre-school autistic children, as identified during the literature review. The proposed model in this research can be used to design interactive MBI's for these children, and it also helps software engineers to expand this project to address other learning deficits in autistic children. The proposed model in this research carries on two strategies together, which are PECS and DS. These strategies have been widely used in learning, and they have shown sufficient effectiveness in learning and training of children with Autism Spectrum Disorder.

The components in the prototype have been used according to the needs of the autistic children as they were proposed in the related studies. The prototype has been designed using the instructions by the Software developers and other researchers in the field.

The proposed model and the designed prototype in this research are easy to understand and can be used by autistic children with minimal instruction without the mediation of a teacher or instructor.

1.8 Research Limitations

The limitation of this study is that it does not consider training to read vocabulary, improving sentence construction and reading comprehension for children with ASD. However, spelling the words can be considered as a future work for this study.

1.9 Structure of the Thesis

Chapter 1: Introduction- This chapter introduces the topic of the research by providing information about the background of the research, research motivation, problem statement, statement of purpose, objectives of the research, scope, and significance of the research. Finally, research limitations and the structure of the current research are also presented.

Chapter 2: Literature Review- In this chapter, a presentation on the related background keywords of this study is given. Further, the chapter's content includes, but not limited to Autism Spectrum Disorder (ASD), dashboards, Mobile-Based Interventions and Autistic children, Vocabulary building disability in Autistic children, Vocabulary building style and Instruction Methods in autistic children, Strategic Interventions of educational methods, and it also presents the current related work.

Chapter 3: Proposed Model- Here, the entire methodology as practiced by this study, is demonstrated. Detailed discussion on each step of the method as applied by the study, are comprehensively discussed.

Chapter 4: Model Implementation and Design- In this chapter, the proposed model has been implemented to design and develop a prototype. It also provides information about the UI design rules and recommendations, followed by screenshots of the developed prototype in this study.

Chapter 5: Evaluation- This chapter provides detailed information about the evaluation of the developed prototype. It also discusses the results of the evaluation and how it will be useful for autistic children.

Chapter 6: Conclusion- This is the conclusion of the overall research, thus it comprehensively discusses how the research objectives were achieved, as well as provided detailed discussion on the study limitations as well as postulated future directions.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

In this chapter, a comprehensive background of the research as well as a critical review of past related work, is being presented. Thus, the chapter commences with an introduction to Autism Spectrum Disorder (ASD) as well as discusses autism's behaviours. Section 2.3 introduces the Mobile-Based Interventions and Autistic children. Sections 2.4, 2.5 and 2.6 discuss the Vocabulary building disability in Autistic children, Vocabulary building style and Instruction Methods in autistic children, SLR on vocabulary instruction strategies for ASD-inclined children, Strategic Interventions of educational methods, PECS (Picture Exchange Communication System) strategic method in education, and DS (Digital Storytelling) strategic method education. Section 2.7 gives a comprehensive discourse on the research related studies. The chapter ends with a brief summary.

2.2 Autism Spectrum Disorder (ASD)

Autism Spectrum Disorder (ASD) is a developmental disorder. ASD consist of 5 subtypes, which are: Rett Syndrome, Childhood Disintegrative Disorder, Autism, Pervasive Development Disorder—Not Otherwise Specified (PDD-NOS), and Asperger syndrome (Association, 2000; Brentani et al., 2013). ASD exists from the early years of childhood or birth, and it is a disorder that disrupts important human behaviours such as imagination, the ability to communicate feelings and ideas, making relationships with others and social interaction. ASD has life-long effects on how kids learn to take care of themselves, to participate in the community, and to be social beings. ASD is originally a neurobiological disorder, which is known by developmental and behavioural features (Naji, Waheeb, & Hamza, 2020).

Autism spectrum disorder (ASD) is considered among the neurodevelopmental problems categorized by shortages in interactions and social communication as well as repetitive and restrictive patterns of behaviours, activities, and interests (Gernsbacher, Morson, & Grace, 2017). People with ASD share specific difficulties, but still, ASD will affect them by their condition in various ways. Some autistic people can live independently while some need specialist support to live their lives. They might also be sensitive to lights, sounds, colours, smells, touch, and flavours. Autism affects the following three skills in autistic people: social interaction (recognizing emotions and expression), repetitive behaviours (adaptation to the environment) and communication (non-verbal and verbal language) (Society, 2015).

Autistic children's behaviours are different from each other: one of them might be bright, engaged, and very verbal, but the other might be intellectually challenged and non-verbal (Sharma, Xenia, & Tarazi, 2018). It is suggested by some studies that ASD can be genetic (Martínez-Pedraza & Carter, 2009; Cavanaugh & Spector, 2015). Centre for Disease Control and Prevention (CDC) made a recent publication which informed that autism continues to increase, as the number of affected children is 1 in 68 children. The number of boys is more than the number of girls at a ratio of 4:1, this means 1:42 boys and 1:189 girls (Baio, 2014).

ASD's symptoms might appear within the first three years of childhood and the effects of ASD might occur later in their life (Martínez-Pedraza & Carter, 2009). Sharma et al., 2018, informed that the amount of identified ASD-inclined children is increasing, thus, most teachers are getting familiar with autistic children (Al-khresheh, 2020). According to the 1997 Educational Act for individuals with disabilities, schools need to provide access to the curricula of general education, for children with disabilities. Autistic

students are increasingly engaged in academic curricula and are placed in common classrooms (Dunlap, Kern, & Worcester, 2001).

The current form of treatment for autism is educating both children and parents, as well as the teachers. Therefore, education is known as the best way of seeking skills or knowledge-not only including academic learning, but also communication, socialization, language, behaviour problems, and adaptive skills to help autistic children develop personal responsibility and independence. Education consists of the services that help the acquisition of knowledge and skills, which are offered by private and public schools as well as other private and public service providers. Children with autism are at a high risk of impairments; therefore, planning for education must fulfil both the needs associated with ASD as well as those associated with other disabilities (Naji et al., 2020).

It is important to note that every autism-inclined child, might display dissimilar behavioural traits from each other. Table 2.1 presents a behavioural list, specifically as regards skills in communication being compiled and consolidated from diverse sources (Brentani et al., 2013; Bosseler & Massaro, 2003; Johnson, 2004). For this research specifically, compiled list of behaviours have been classified into four groups, which are hinged on similarities existing among the behaviours. The categories include: 1) language comprehension, 2) general behaviours 3) non-verbal communication and 4) verbal communication.

Table 2.1: Categorization of Autism's Behavioural Associated with Social-Communication Skills (Brentani et al., 2013; Bosseler & Massaro, 2003; Johnson, 2004)

Language comprehension	General behaviours	Non-verbal communication	Verbal communication
1. Probable slow language development. 2. Difficult understanding to words. 3. Difficulty to identify nouns. 4. Probable delay in content and grammar. 5. Inappropriate use of verbs.	1. Give unrelated answers to questions. 2. Non-responding in normal methods of teaching. 3. Less likely to share.	1. Use fewer gestures. 2. Do not understand teasing, or jokes. 3. Find it difficult in following directions. 4. Seems to lack hearing sometimes. 5. Do not pretend in play.	1. Unable to express needs & needs. 2. No consistent response to name. 3. Speech may be delayed. 4. Repeating words of others.

2.3 Mobile-Based Interventions and Autistic children

Several studies have conveyed that individuals with ASD can deal with mobile-based interventions better than with humans (Lahiri, 2020; Yee, 2013; Fteiha, 2017). People with autism prefer mobile applications due to the routine and repetitive behaviours in the applications' environments (Koumpouros & Kafazis, 2019). Tutors in the virtual environment have been effective to help children with ASD, who are weak in social and communication interactions (Mkpojiogu et al., 2018).

Traditional ways of teaching autistic children by human tutors are challenging for them and cannot fulfil the needs of each autistic kid, whereas the tutors in a virtual environment can meet their needs. The reason is that children with ASD don't show comfortableness while looking at faces, but tutors in the virtual environment usually look like a cartoon and children with ASD are comfortable with them. At the same time, in a virtual

environment, it is possible to arrange the contents of the session according to the children's understanding level. It is suggested by some studies that children with ASD gain more information when they are taught by tutors in a virtual environment, as compared to those who are taught by human tutors (Moore & Calvert, 2014).

Children with ASD can benefit from virtual tutors much more than human tutors, for example, teaching and practice with virtual tutors are not limited but human tutors might face pressure and tiredness after a limited number of tasks or practices (Fan et al., 2020). Due to the abnormal sleep patterns in children with ASD, virtual tutors can further benefit them by being available at any time, but human tutors will need some rest. At the same time, human tutors need a proper schedule to work with, but virtual tutors are suitable with any schedule and in any number of hours for practice (Joseph et al., 2019). An effective method for teaching children with learning disabilities is the use of mobile-based learning systems (Sung et al., 2015).

An interactive learning environment is provided by the mobile and technology-based methods for children (Mohammad et al., 2019). It is suggested by researchers to use mobile-based interventions as a support tool for teaching kids with autism and those interventions are broadly used in the special education area (Eutsler et al., 2020). Autistic kids usually need more one-to-one guidance for better performance. Mobile-based interventions help them work independently with an unlimited number of practices, which will increase learning possibilities in kids and will improve their social behaviour and attention span (Sofian et al., 2018).

Furthermore, review studies specifically written on mobile applications for Autism Spectrum Disorder (ASD) inclined children, which seeks to know how it influences them significantly, are in existence (Mkpojiogu et al., 2018; Genc, Masalimova, Platonova, & Sizova, 2019). The researchers analysed diverse mobile application types of availability

for ASD-inclined children. The results from this analysis show that MBI has been extensively utilized in providing extra skills associated with ASD-inclined children, nevertheless, there are fewer studies and applications on MBI with regards to the support of ASD inclined preschool children for vocabulary learning (Xanthopoulou, Kokkalia, & Drigas, 2019; Crespo & Martin, 2016).

2.4 Vocabulary building disability in Autistic children

Impairments in specific cognitive processing styles, social skills, and communication can affect the academic performance of students with ASD. A difference is seen between the predicted skill level of students on intellectual functioning and their actual success in basic number of skills, vocabulary building, reading, and spelling (Luyster & Lord, 2011). The ability to learn a new word is known as one of the most important outcomes in children's education (Walker & Carta, 2019). For children with ASD to be independent in adulthood, it is required for them to have abilities further than communication and social skills, especially reading skills. New words learning is an essential skill, that can increase reading chances, future employment, general quality of life, and adaptive living skills (Joseph et al., 2019).

Consequently, some authors have tested reading skills (e.g., text comprehension, recognition of word(s), accuracy in reading text(s), and non-word decoding) in children with ASD (containing 16 children with autism, 12 with Asperger syndrome and 13 with atypical autism) (Nation, Clarke, Barry, & Christine, 2006). The result of that test specified that a large number of those children displayed deficiencies in the comprehension of the text, vocabulary, and oral language (Nation et al., 2006).

To read a sentence, several skills are required, such as recognizing each letter, group of letters, and recognition of the word (Walker & Carta, 2019). In the preschool, children usually learn to recognize new words; they need to read and understand simple sentences

(Ventura & John, 2009). Later on, reading becomes more complicated for them, concentrating on grammatical points and growing vocabulary (Nally et al., 2018). Studies have shown that challenges are faced by students with autism spectrum disorder (ASD) with regards to literacy skills (e.g., vocabulary building, reading, writing, …) (Spector & Cavanaugh, 2015; Al-khresheh, 2020; Luyster & Lord, 2011). An appropriate time for learning new words is the first years of childhood (Gernsbacher et al., 2017). Current studies show that children with ASD have deficiencies in vocabulary building skills even before starting school (Naji et al., 2020; Society, 2015).

The National Reading Panel (NRP) is a research organization in which there are researchers from different areas, such as higher education, psychology, and reading education; this organization aims to examine the effectiveness of different strategies on how to read (Cunningham, 2001). They have recognized five important components of reading, which are text comprehension instruction, vocabulary instruction, oral reading fluency, phonemic awareness, and phonics. The NRP has recommended different approaches related to each of the components. Association methods, indirect instruction, multimedia instruction, capacity methods, and explicit instruction are the strategies for vocabulary instruction while question answering, graphic and semantic organizers, cooperative learning, question generation, story structure, summarization, and comprehension monitoring are the strategies for text comprehension instruction (Khowaja & Salim, 2013).

2.5 Vocabulary building style and Instruction Methods in autistic children

This research is targeted at providing a platform where autism-inclined children can learn vocabulary; thus, this section presents a review conducted to garner further understanding on research related vocabulary works that have been conducted on ASD children. The major aim of vocabulary learning is the comprehensibility of the read text

(Khowaja, Banire, Al-Thani, & Sqalli, 2020; Basil & Reyes, 2003b), which is considerably "the utmost essential academic skill learned in school" (Mastropieri & Scruggs, 1997). Further, two imperative components makes up reading comprehension, they are: Language Comprehension and Decoding (Ricketts, 2011; Duff & Clarke, 2011). Decoding refers to the ability of speech translation from text. On the other hand, language comprehension refers to the ability of understanding spoken language. Thus, if a child has the ability of decoding and understand a text, this implies the readability status of the child, i.e. he/she is reads (Browder, Wakeman, Spooner, Ahlgrim-Delzell, & Algozzine, 2006; Fteiha, 2017). Additionally, several processes are involved, including visual perception as regards the discrimination of printed letters, identification of letters in reflex to word components, as well as word meaning interpretation.

One of the most vital as well as foundational component of langue is vocabulary. It refers to a group of words that provides the foundations for language development of any kind. Learning cycle as well as vocabulary development of children begins at their tender age, after which they continuously develop their vocabulary as toddlers, for example, as they hear people around them, speak, they also begin to speak. Thence, there is a constant evolvement of an individual's vocabulary, as they begin to read diverse materials as well as involve in communication with people. Imperatively, there is a direct influence of learning vocabulary on reading comprehension (Mastropieri & Scruggs, 1997; Spector & Cavanaugh, 2015). Combining pictures together with text, leads to an effective communication mode as well as instruction for autism-inclined children, as it helps them with word memorization alongside the meaning of the word, while being spoken.

As informed by Luyster & Lord (2011), it is possible for autistic-inclined children to be independent vocabulary learners if there is a suitable instruction medium for teaching novel words. Thus, the simplicity level of directly learning an individual word has an

impact on the teaching depth. A word representing an object with an associated corresponding picture, can be easily comprehended and learnt by autism-inclined children (Luyster & Lord, 2011). According to Ventura & John (2009), teaching of diverse words should be via different techniques of instruction. The learning of words via instruction from a contextual basis, comprises the construction of sentences through the use of novel words as well as discussion of several meanings of same word, when being used in different sentences. Consequently, autistic-inclined children need instructions that are specialized, regardless of the prospective taught contents, thus, understanding the techniques being utilized by the teachers as well as researchers in motivating these children to maintain focus in learning, is very important (Ventura & John, 2009). Accordingly, some systematic literature reviews (SLR) (Mkpojiogu et al., 2018; Ostryn, Wolfe, & Rusch, 2008; Logan, 2017; Fan et al., 2020; Griffith, Hagan, Heymann, Heflin, & Bagner, 2020; Shoaib, Hussain, Mirza, & Tayyab, 2017; Khowaja & Salim, 2013; Sormunen & Saaranen, 2020; Koumpouros & Kafazis, 2019) on reading comprehension and MBI for autism-inclined children were conducted with sole purpose of identifying: 1) strategies used in related studies; 2) potential benefits of using MBI to teach vocabulary and reading comprehension with the above-mentioned strategies; 3) vocabulary building model or framework used in related studies. The review began initially with emphasis on related reading language comprehension of reading comprehension related studies, however limit in the amount of studies discovered, led to an expansion in the gathering of additional information which was achieved via the inclusion of the decoding aspect of reading comprehension, as reviewed. The next sub-section presents a summary of the SLR.

2.5.1 SLR on strategies used for vocabulary instruction of children with ASD

Key findings from the SLR conducted on strategies and MBIs, are presented in this section (Mkpojiogu et al., 2018; Ostryn, Wolfe, & Rusch, 2008; Logan, 2017; Fan et al.,

2020; Griffith, Hagan, Heymann, Heflin, & Bagner, 2020; Shoaib, Hussain, Mirza, & Tayyab, 2017; Khowaja & Salim, 2013; Sormunen & Saaranen, 2020; Koumpouros & Kafazis, 2019).

1. Multimedia instruction as well as strategies for explicit instruction that are extensively used in teaching vocabulary to autism-inclined children.
2. MBI usage is very promising, as it is hinged on significant improvement between pre-test and post-test results.
3. Unavailability of the vocabulary builder design framework or model for autistic children.
4. Quite a small amount of MBI varieties have been developed for vocabulary instruction; MBIs comprises multimedia based application for interaction with autistic children.
5. Digital storytelling instruction is a less utilized strategy for teaching vocabulary to preschool children with autism.

2.6 Strategic Interventions of educational methods

A lot of challenges exist with regards to learning for ASD inclined persons, however, learning styles that can help in enhancing the process of learning and new word retention, are already available. From the review of studies, which is a phase of SLR as regards strategies, some researchers (Bondy, 2017; Bosseler & Massaro, 2003; Fan et al., 2020; Novack et al., 2019) emphasised that further investigation is needed on finding out how multiple modalities impacts language learning for autism-inclined children. Importantly, the ASD-inclined children need a lot of one-to-one instructions. Mobile-based intervention (MBI), which is used extensively within the special education sector has been postulated to be an adequate tool that can support teachers of ASD-inclined children (Genc et al., 2019; Wojciechowski & Al-Musawi, 2017). Further, MBI for ASD-inclined

children, makes use of diverse modalities, such as audio, text, images, among others, for interacting with the children. Learning for this children is achieved by using at least one or more modalities based on availability from MBI (Sung et al., 2015). Modality refers to a "communication channel type that is used in conveying or acquiring information" (Khowaja et al., 2019).

Furthermore, from the SLR past studies on strategies, it was revealed that multimedia instruction as well as explicit instruction are extensively used strategies for teaching vocabulary to autism-inclined children, however digital storytelling instruction is less implemented strategy (Bosseler & Massaro, 2003). The emphasis of the review for this section is on the two types of education strategic methods, which are: 1) PECS strategic method Interventions, and 2) DS strategic method Interventions.

2.6.1 PECS (Picture Exchange Communication System) strategic method in education

The Picture Exchange Communication System (PECS) refers to an alternative as well as augmentative system of communication, developed and produced by Pyramid Educational Consultants, Inc. PECS was developed in 1985 at the Delaware Autism Program by Andy Bondy, and Lori Frost (Bondy & Frost, 2001). The aforementioned scholars who developed PECS, discovered that techniques of traditional communication, which included, picture point systems, speed imitation, and sign language, were reliant on the teacher for initiating social interactions, yet none was focused on teaching the students to be able to ensure interaction initiation. With respect to the aforementioned observations, the scholars, Bondy & Frost, created a functional communication medium for persons with diverse challenges of communication (Bondy & Frost, 2001). Even though, the original aim of developing PECS was for ASD-inclined children, yet its use is getting used extensively. Over the decades, PECS has achieved successful

implementation of persons having diverse diagnoses, across different age groups. Correspondingly, PECS is a practice based on evidence, which has attained huge success as regarding functional skills development (Bondy, 2017; Jurgens, Anderson, & Moore, 2014).

The protocol used for training is hinged on applied behaviour analysis principles (Griffith et al., 2020). The aim of PECS is to provide a communication that is functional as well as spontaneous (Bourque & Brady, 2016). Furthermore, the teaching portal of PECS is based on B. F. Skinner's book, Verbal Behaviour, where in operates of function verbal are taught systematically via reinforcement and prompting strategies, which results into independent communication. Consequently, verbal prompts are not utilized, thence leading to the building of immediate initiation as well as prompt dependency avoidance. PECS starts with a student being taught on exchanging a desired item's picture card with a partner in communication, who spontaneously honours the request. Preceding the spontaneous request learning by the student for a desired item, the stem then proceeds with teaching symbols discrimination and further moves to how a simple sentence can be constructed. For most advanced stages, they system teaches the individuals on the manner of responding questions as well as how to comment. In addition, other descriptive concepts of language are taught, such as shape, number, size, shape, colour, etc., this is done to enable the students learn the art of being more specific in their messages, an example of which is: "I want big yellow ball" (Douglas & Gerde, 2019; Sharma et al., 2018).

Evidences exist as to the ease of learning PECS by majority of students, with its primary benefit as a communication medium for adults and children who have limited/no speech as a result of autism or other disorders in communication (Douglas & Gerde, 2019). Thus, the consensus from majority of researchers is: "PECS can be recommended

as an evidence-based intervention to enhance communication skills that are functional for individuals with ASD" (Bourque & Brady, 2016). One of the initial concerns was the possibility of delay or inhibiting of speech development by PECS. However, from a recent review on several peer reviewed studies, it was discovered that " no evidence exists from reviewed studies with regards the suggestion of speech inhibition by PECS; and contrariwise, if there was an observation of any effect, instead of it being inhibitory, it would be facilitative" (Bondy, 2017). Thus, when there is a case of difficulties, it is mostly as a result of the lack of powerful reinforcement and/or error from the trainer (Sharma et al., 2018). Further, report from a systematic intervention review for autism spectrum disorderly inclined children, indicated that there is a short term improvement in acquisition of words, however the effects are not maintained over time (Ostryn et al., 2008).

Adams-Hill and Flores (2014) carried out an alternating single-subject treatment study with the sole aim of finding out if the use of a technology-based communication system (iPad) or a low-tech (PECS) system was of more effect with regards to the promotion of the independent use of the provided system. The participants in their study comprised 5 students, with age range from 3-9 years old. Further, 3 of the students were autism-inclined children, while the other two has developmental delays. Overall, it was revealed that PECS might be more preferable at earlier communication stages, also iPad implementation may be of benefits once a communication repertoire has been established in the student. Thus, there would be a need for PECS to be transport and handle diverse cards, whereas transportation of iPad is much easier as it is of more compact. Also, it was discovered that PECS was able to promote spontaneous speech, while on the other hand, iPad generates speech only when the icon is pressed, thus allowing the it to speak for the student, instead of allowing the students produce their own speech (Flores & Hill, 2014).

2.6.2 DS (Digital Storytelling) strategic method education

In accordance to the extensive use of digital media, its development has taken a diverse form as regarding how it's been created and presented. Digital storytelling (DS) is hinged on digital images, text, sounds and videos, all forming a genre for the purpose of presenting a story to listeners, readers, and viewers via a computer system (Schwartz & Beck, 2020; Parsons, Guldberg, Porayska-pomsta, & Lee, 2015). Educationally, novel methods of instructions, based on technology-use, has been developed to help facilitate learning. As argued by Rahimi & Yadollahi (2017), adjustments are made on concepts that are known in a novel pedagogical setting, and are further enhanced via technology use (Rahimi & Yadollahi, 2017).

Moreover, there are numerous benefits attached to digital storytelling, especially in the educational process in different domains as well for diverse groups of learning (Sormunen & Saaranen, 2020; Hanrahan, Smith, Johnson, Constantin, & Brosnan, 2020; Wyatt & Hauenstein, 2008). Specifically, Rahimi & Yadollahi (2017) suggested that students can be assisted via digital storytelling programs, to ensure improvement of their vocabulary build-up, writing and reading skills, this is so as there is a need for learns to create as well as organize image sequences to align with their story making ideas. It was also concluded that DS has the ability to increase engagement as well as creativity among students, thus enabling them discover diverse ways of expressing their personal ideologies (Rahimi & Yadollahi, 2017). Also, some other scholars, such as Valkanova & Watts (2007), in their experiment requested that children make sound, in form of a "voice over" narratively in a means of forming their own videos. From this work, the researchers reported that such procedure gave the children the ability to verbally as well as visually express themselves, this they did in an artistic, inspiring and productive manner (Valkanova & Watts, 2007). Similar inference was reached by Parsons et al.(2015), in their research, evidence was offered in-line with DS positive effects for creative thinking (Parsons et al., 2015).

Mariotti (2012) explored teaching and learning via digital storytelling application with Microsoft Photo Story 3. The scholar discovered there was an increase in the learning and comprehension of the students. Furthermore, Daigle (2008) made some observations that students has higher activeness and engagement with the subject matter when they make use of multimedia software in visualizing their thoughts. Consequently, Li (2007) conducted some evaluations on how multimedia technologies could be integrated into higher education, of which it was concluded that the vocabulary learning of the students were improved via DS. More so, DS has been used as a medium of education for special need-based learners (Li, 2007). Proctor (2007) made use of digital story books to successfully teach students with difficulties in learning, literacy.

In general, majority researchers are of the opinion that DS is a very effective method of engagement for students as well as support for teachers in effectively integrating technology to learning. Correspondingly, its application as regards special learning groups, has also been studied a bit in literature (Xin, 2014; Onuorah, 2020; Valkanova & Watts, 2007). Investigations has been made as well in the implementation of DS to ASD-inclined students as regards scheduling of activities via computer applications (Parsons et al., 2015; Parsons, Ivil, Kovshoff, & Karakosta, 2020). These scheduling of activities refer to set of pictures/words that prompts a person to engage in series of activities (Hanrahan et al., 2020; Valkanova & Watts, 2007). The activities could be considered as a manner of telling stories, since they are mostly familiar with sequence steps display in completing pending activities, which could lead to the formation of a story that is constructed via a series of text and images. Consequently, the probable benefits of scheduling activities presented with computer support are properly documented in literature (Onuorah, 2020).

Contemporarily, the pervasiveness of technology impact on every area of people's life, has resulted into the sprouting up of new generation stories, such as digital storytelling. Digital storytelling can be referred to as the means of integrating computer inclined technologies into the storytelling art, thus "blending the media to both enhance as well as enrich either the spoken or written word" (Rahimi & Yadollahi, 2017). DS is both a valuable teaching procedure and content which helps in inspiring active/lively learning as well as ensure the "creation of an exciting and fun-filled atmosphere, thus fostering the adequate technology use within the curriculum, as well as bride community and school, weaving into all aspects of study and is of much effectiveness for both auditory as well as visual learners" (Rahimi & Yadollahi, 2017). Further, digital storytelling has been discovered to help in facilitating skills of self-expressiveness and communication, thus enhancing the development of the ability to solve problems, vocabulary learning, and motivational practices (Sormunen & Saaranen, 2020).

Thus, based on the facts that digital stories core value is the language, there has been a recent attraction from language educationist, as they have been impacted by the making language learning digital stories. Consequently, the positive effects of digital stories as related to its role improving the vocabulary learning of learners (Sarıca & Usluel, 2016) and oral skills (Yang-Ha Hwang, Yong-Won Kim, & David S. Liebeskind, 2016), alongside the motivation to learn a language, as well as critical thinking (Yang & Wu, 2012) are reported in literature. The findings from these studies in general, postulates that via implantation of digital storytelling, there would be additional chances for students to learn vocabulary, thus providing them with social and cognitive development via language skills (Schwartz & Beck, 2020).

Furthermore, from the established framework, focus has been made by one string of research on the investigation of the role digital stories making play with regards to

instruction. Thus, putting consideration on the social and cognitive nature of vocabulary, digital storytelling is able to make provision for student writers, by offering "a lot of opportunities for interaction as well as language utilization in the most personally meaningful and authentic ways" (Rance-roney, 2008). More emphasis is placed on the fact that there is a capability of increasing the motivation of students to vocabulary learning by digital storytelling, as well as further stimulating students who lack tendencies of learning or lack confidence in building vocabulary itself (Khowaja, Al-Thani, Hassan, & Shah, 2020). Evidences also exist that supports digital storytelling impact on developing writing skills among learners of second language via teamwork and collaboration (e.g., Sarıca & Usluel, 2016). Nevertheless, just a little knowledge is established as regarding how telling, making, and using digital stories could impact the literacy skills of learners in preschool (this includes both reading as well as vocabulary comprehension). Also, different technologies can be used digital storytelling literature, some of which includes, animation, picture, text, and audio (Parsons, Ivil, Kovshoff, & Karakosta, 2020; Wyatt & Hauenstein, 2008).

2.7 Related Work

As discussed in the section 2.2, the associated behaviours with children communication skills are being categorized into four parts, which are: verbal communication, non-verbal communication, general behaviours, and language comprehension. This study selected related works from ASD inclined children's comprehension skills that can be used in supporting the children to be able to learn several vocabulary types. The literature review of related works is presented in two groups. The first group reviews research including MBI design for addressing language comprehension skills in the deficits of vocabulary learning by ASD inclined children. The second phase reviews studies that made use of strategic education approaches, such as PECS or DS to address the difficulties in literacy of ASD inclined children.

2.7.1 Vocabulary Learning related MBI for kids with ASD

There is a large number of studies that have either proposed or designed mobile-based interventions for children with ASD in different areas for treatment or teaching purposes. These studies address improving the social and communication skills, improving job and interview skills, improving face and emotion recognition, self-injuries, behavioural learnings, attention, education and literacy (Novack et al., 2019; Mohammad et al., 2019; Khowaja, Al-Thani, Hassan, & Shah, 2020).

In this research, five studies were identified that address vocabulary learning deficits in children with ASD and have been published from 2013 to 2020. These studies have been selected from the domains of language comprehension skills. The basic details about the studies are listed in Table 2.2.

In the first study (Husni & Budianingsih, 2013) included in this review, the authors have proposed a mobile-based vocabulary learning application which will help developers to develop appropriate learning tools for Autistic children. This is a client server application on the client side. In this study, a Hybrid a picture or a cartoon character with music for learning vocabulary prototype has been developed to teach words to children with ASD. The results from the application evaluation revealed that there was satisfaction among majority of users, as regarding the application, thus indicating that around sixty percent of the recommended application is deemed fit to be used as a learning tool for children with autism.

In the 2nd study (Tang & Winoto, 2018), here, the author presents two flexible and individually adaptable picture-based word-learning mobile applications such as Swipe-N-Tag, and Snap-N-Recognize. The iOS version of Swipe-N-Tag was tested with a small number of autism children in a private autism centre, thus producing very reliable results. Further, while learning activities were on-going, the children were shown a set of words

and asked to make some construction by tapping certain items in a photo to read/listen to the recorded words. Also, in the 'Snap-N-Recognize', teachers would first take some photos of an item that is targeted and ensure their instruction is recorded. Afterwards, they will request the children to match word to photo, containing the targeted item that need to be learnt. As presented in the result of the test, they have noted improvements in the performance of the students in image matching with word.

Table 2.2: Recent Studies Related to Mobile-Based Vocabulary Learning

No	Authors	Title	Year	Focus of study
1	Husni & Budianingsih	Mobile Applications BIUTIS: Let's Study Vocabulary Learning as a Media for Children with Autism	2013	Vocabulary learning
2	Tang & Winoto	Poster: Two Lightweight and Customizable Picture-based Word-Learning Mobile Applications for Chinese Children with Autism	2018	Word learning
3	Soomro & Soomro	Autism Children's App using PECS	2018	Single word learning
4	Maulana & Bahruni	An Android-Based Vocabulary Model For Autism	2020	Improve English language
5	Husni & Budianingsih	AutiShapes: Learning Shapes Game for Autistic Children on Mobile Application	2017	Matching word with shape

The 3rd study in this review (Soomro & Soomro, 2018), is an Android based mobile application, which provides a more suitable learning environment, including graphical representations. It is a mobile-based application which has been developed to help autistic

children to learn single word with subcategories such as animals, colours, shapes, fruits, and vegetables. Each subcategory comprises words with pictures as well as audio cues so that the children can learn by reading, visualizing and listening. In the course of the learning activities, the children were shown set of words, and were requested to make a sentence construction via a process of whole-word selection. Thus, they complete a sentence construction by dragging whole words to any space in the sentence of their choice. For testing this intervention, autistic children, and kids' parent participated and evaluated the intervention. Besides, the authors had provided them with a questionnaire and by getting feedback from the participants, they reported that there was an accepted level of satisfaction by the participants with the system. In this system, they also used Picture Exchange Communication System (PECS). Results from the evaluation indicated that PECS' inclusion assisted the ASD inclined children to enjoy more suitable communication as well as improved learning, thus indicating that the Picture Exchange Communication System (PECS) proved to be a more suitable choice to be integrated with the app.

The 4th study in this review (Maulana & Bahruni, 2020), is a mobile-based English learning intervention which is used to teach word learning to children with autism. In this paper, the authors have developed a mobile-based intervention using android. They have used words lists in two phases to teach students how to read those words. On this page, users can see images of each vocabulary and hear the vocabulary pronunciation in English. They just click on the speaker image. At the end, they noticed improvements in the children's performance in reading, informing thus that the application can facilitate the process of learning English in particular or other languages for autistic children.

The last paper in this review (Sadry & Ismail, 2017), is a mobile application to develop a learning shapes game for Autistic children. In this paper, the authors developed a

mobile-based intervention using android. AutiShapes app is an application that helps children match the word given in option with shapes such as square, triangle, circle, and rectangle. The result of this project is the AutiShapes 2D game, which have been integrated with mobile application and tested by the Autistic children at Louis Centre. At the end, they authors noticed improvements in the children's performance to learn shapes with word. This study doesn't use voice for pronouncing the words, which is a limitation for pronouncing the words to the students to learn how to read a word.

2.7.2 Educational method-based technology Interventions

A lot of technology-based inventions such as MBI (Mobile-Based Intervention) and Computer-Based learning applications, have been developed to help autistic children by using Educational Methods Interventions. These interventions have used either PECS or DS as a tool for interaction between the children and the intervention. In this research, we will describe some of these interventions that have been proposed or have been developed to address learning and literacy deficits in children with autism. These studies have been selected from the domains of language comprehension skills. Table 2.3 shows the details of the studies included in this review.

Table 2.3: Recent Studies Related to PECS & DS Method to Address Learning

No	Authors	Title	Year	Methods	Focus of study
1	Basil & Reyes	Acquisition of literacy skills by children with severe disability.	2003	PECS	Words, sentences, and reading comprehension
2	Hetzroni & Shalem	From logos to orthographic symbols: A multilevel fading computer program for teaching nonverbal children with autism	2005	PECS	Matching word to sample
3	Al-Khafaji, Al-Shaher, Hassan, & Al-Khafaji	M-Learning Application for Autistic Children using Android Platform	2013	PECS, sound	Teaching alphabet

4	Magiati & Howlin	A pilot evaluation study of the Picture Exchange Communication System (PECS) for children with autism	2003	PECS	Teaching simple words
5	Soomro & Soomro	Autism Children's App using PECS	2018	PECS	Single word learning
6	Mariotti	An exploration of using ipads and digital storytelling through westories with students who have autism	2012	DS, audio, image	Improve language comprehension
7	Chatzara, Karagiannidis, & Mavropoulou	Digital Storytelling for Children with Autism: Software Development and Pilot Application	2015	DS, text and image	Vocabulary learning

In the first paper of the studies (Basil & Reyes, 2003), the authors have used supported PECS based on "Delta Message". This is a CBI-Based program which is designed for word learning activities and improvement in sentence production. In the course of the learning activities, a set of words was shown to the children, after which they were asked to make a sentence construction by using the process of whole-word selection. After completing a sentence, they are to drag the whole words into the sentence of interest. However, in the course of the test task, the aforementioned process took place reversely. This implies that the students were requested to make construction of appropriate sentences, which describes the actions depicted by the image. The results revealed that they improved on identifying pictures and vocabulary production of sentences that were of target at the program.

Authors in the second study (Hetzroni & Shalem, 2005), used PECS covered teaching of correct matches between text and food symbols and a computer to help autism children. The authors made use of a 7-step fading procedure in teaching word identification from

commercial accessible logs depicting food items. Results revealed that children found it possible to identify between text and food symbols, thus maintain the performance over the time frame set. Also, the children were able to make generalizations with day to day activities around the class.

Another group of researchers (Al-Khafaji et al., 2013), developed a PECS-based and M-Learning Application using Android Platform to help autistic children with learning alphabet problems. In this program, a list of alphabets is displayed to the children on a mobile application and the children then picks any letter of their choice. Afterwards, there is a display of words on the system, beginning with the exact letter of choice by the child. Thence, the author made a comparison on learning of words by children, following, and motivation, via MBI, alongside behavioural traits, as programmed in what the teacher was involved in. Further, the MBI utilized various basic modalities. As indicated by the authors, it was revealed that there was an increase in attentiveness alongside motivation by the children when they made use of MBI, thus they were able to learn additional words, as well as increase the comprehension ability of their reading and vocabulary.

Magiati & Howlin, 2003 developed a pilot study conducted for evaluating the effects of training teachers of ASD inclined children using PECS. This study was developed for thirty-four autistic children to teach them learning. The data regarding the children's PECS use revealed that, there was a record of rapid and significant increases in the level of PECS that the children attained, alongside their PECS vocabulary, and in their PECS frequency usage over time. Result indicated that, there is tendency of supporting formal PECS training positive effects, based on the significant increase in the PECS use of the children undergoing training, as well as the highly positive views of the teachers alongside the parents in the program, thus inferring the essentiality of the use of PECS training.

In the work of Soomro & Soomro, 2018, a mobile-based application using the PECS method was developed to help autistic children to learn a single word with subcategories such as animals, colours, shapes, fruits, and vegetables. Evaluation results reveal that PECS's inclusion, assisted the ASD-inclined children to enjoy more suitable communication and improved learning, this suggesting that PECS could be a more appropriate choice for integration with the app.

The authors in (Mariotti, 2012) developed an iPad-based application using weStories, a type of digital storytelling, and the use of iPads among second and third grade students who have autism. This application was developed for individuals to learn the fundamental story-telling and narrative skills, so as to increase their communication as well as literacy skills.

Finally, from the work of Chatzara et al., 2015, the authors developed a pilot application of "DiSSA" with DS software, to help in the development process of autism-inclined children. Photo Story by Microsoft, which is "visual", was the software used. This application also utilizes great visual processing, as well as presents structural information via technology systems, as it has the potentials of becoming a suitable technique for teaching language comprehension skills to these children.

2.8 Summary

From reviewing the literature, the following gaps are identified form the literature:

1. PECS and DS have been widely used for teaching and learning purposes, and most of the studies have noticed improvements in their audiences (Logan, 2017; Fan et al., 2020; Kravits et al., 2002; Bourque & Brady, 2016).

2. PECS and DS are better alternatives to human tutors (Bondy & Frost, 2001; Howlin, Gordon, Pasco, Wade, & Charman, 2007; Bondy, 2017; Chatzara et al., 2015).
3. Children with autism have shown interest in the digital storytelling-based programs and they have performed better when using the digital storytelling-based MBI (Cerezo, Calderón, & Romero, 2019; Conte, Ferreira, & Ramírez, 2020; Sung et al., 2015; Wojciechowski & Al-Musawi, 2017).
4. The existing studies from the domains of language comprehension skills revealed that there are very few studies that used DS for vocabulary learning of autistic children (Schwartz & Beck, 2020; Parsons, Ivil, Kovshoff, & Karakosta, 2020; Parsons, Guldberg, Porayska-pomsta, & Lee, 2015).
5. Finally, there are very few studies from the domains of language comprehension skills that addressed vocabulary learning deficits of autistic children (Khowaja & Salim, 2013; Naji et al., 2020; Abidoğlu, Ertuğruloğlu, & Büyükeğilmez, 2017).

The next chapter in short, there is a high need to be develop a model to facilitate the reading of autistic kids especially the young ones using technologies of PECS and DS so that to assess their usefulness and effectiveness.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the methodology used in conducting this study. Section 3.2 presents the overview for the research methodology. The overview gives a brief description of all steps employed in condign this study. More comprehensive details of each steps are presented from Section 3.3 to Section 3.7. The chapter concludes with a summary.

3.2 Overview

This study target is the design and development of an English vocabulary builder model prototype. As long as this study deals with the development and evaluation of a prototype, we use the Design Science Research Method (DSRM), which has been suggested in literature (Peffers et al., 2007). DSRM is a systematic methodology for developing and evaluating an artifact to come out with a solution for a specific problem. Therefore, this method is used in this study with a focus on a systematic literature review for identifying the problem, developing an artifact (English vocabulary builder model prototype in this research), demonstrating the use of it, evaluate it to ensure about the effectiveness and communicating the results with the audiences. Several steps are carried out as presented in Figure 3.1, which shows the process model for DSRM in achieving the study's objective.

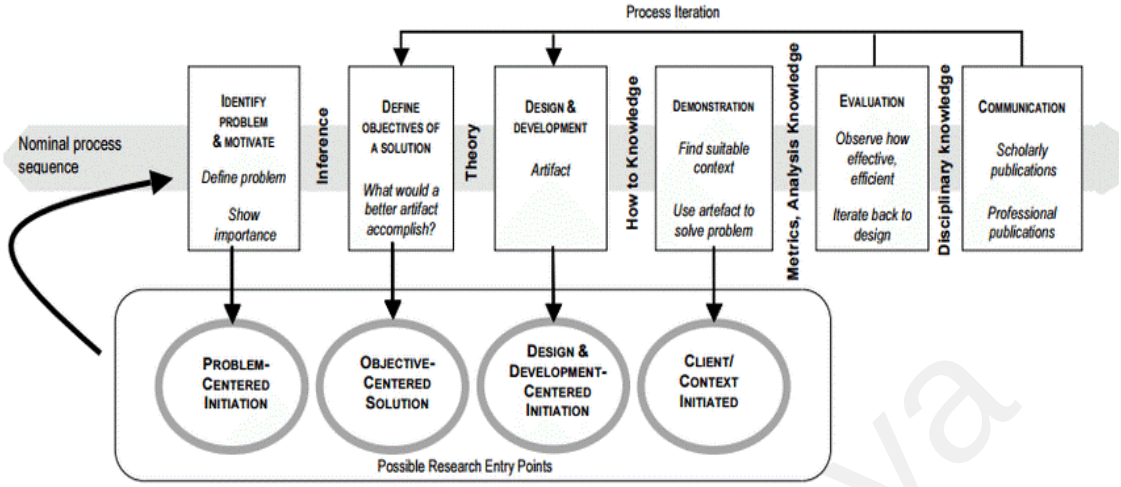

Figure 3.1: DSRM Model (Peffers et al., 2007)

The processes of DSRM, the relations between DSRM steps and this research's objectives, and how the RQs have been answered are shown in Figure 3.2 and Figure 3.3 below.

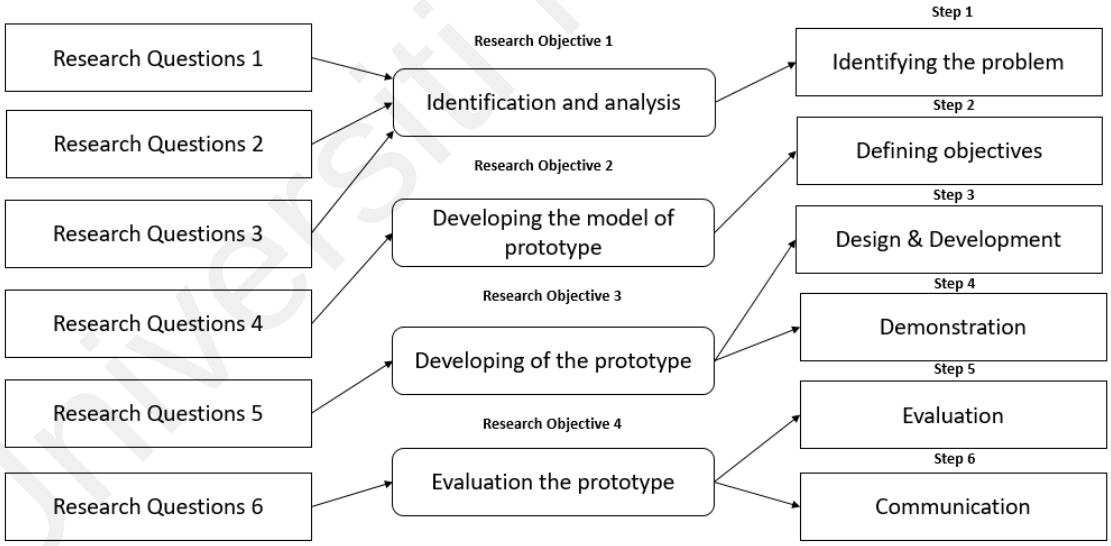

Figure 3.2: DSRM Implementation in this Research

Figure 3.2 shows how DSRM is used in this research to perform the research objectives and answer the research questions, while Figure 3.3 shows the relationship between DSRM model's steps and the related activities in the current research. The detailed description of all steps of DSRM is presented below.

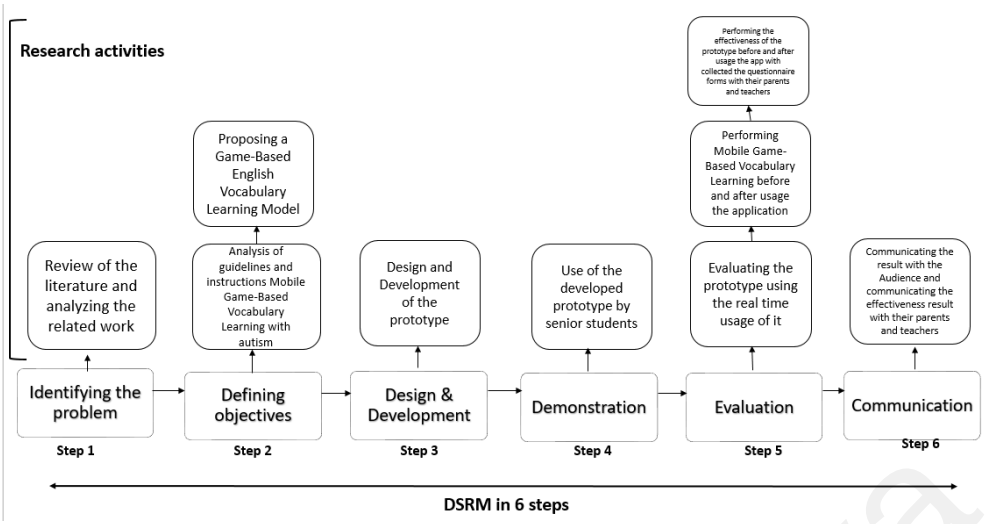

Figure 3.3: Relationship of the DSRM Model with the Activities of this Research

The steps carried out in the carrying out this study is presented thus:

a) Step 1: Systematic Literature Review (Section 3.3)

b) Step 2: Identifying the problem and motivation (Section 3.4)

c) Step 3: Defining objectives of a solution (Section 3.5)

d) Step 4: Designing and development (Section 3.6)

   i. Step 4a: Design Guidelines and Recommendations.

   ii. Step 4b: Interaction.

   iii. Step 4c: Presentations.

   iv. Step 4d: Navigation and Page Loading.

   v. Step 4e: Personalization.

e) Step 5: Demonstration (Section 3.7)

f) Step 6: Evaluation (Section 3.8)

g) Step 7: Communication (Section 3.9)

3.3 Systematic Literature Review

The goal of conducting Systematic Literature Review (SLR) for this study is to extract information from related studies, carried out by previous works. Information related to the Autism Spectrum Disorder (ASD), mobile-based Interventions and autistic children, vocabulary building disability in autistic children, vocabulary building style and Instructional methods in autistic children, SLR on strategies used for the vocabulary instruction of children with ASD, strategic interventions of educational methods, PECS strategic method in Education, and DS strategic method in Education, were gathered via a thorough process. Further, review of related studies was undergone to establish adequate understanding of the entire study area, as well as understand the methods of implantation with regards to the design and development of an English vocabulary builder in each respective domain.

Search was performed from diverse digital libraries in conducting this research. The study conducted a critical literature review on journal articles, technical reports, book chapters, and books, for the purpose of having adequate understanding of related areas to the subject topic, vocabulary builder, afterwards propose a new process model to design a prototype for an English vocabulary builder, for autistic children. The conduct of the search is hinged on some relevant digital libraries given thus:

A. ACM.
B. Google Scholar.
C. IEE Explore.
D. Science Direct.
E. Springer Link.
F. Web of Science.

3.3.1 Search Method

An established process as defined by Kitchenham, 2004 was employed in conducting the review. The following steps comprise the process:

3.3.2 Planning the review

In carrying out the search from selected journals and databases (Section 3.3), the inclusion criteria are explained in this section.

3.3.2.1 Overall Review

The review commenced by the identification of related studies with the constituents of language comprehension skills for ASD-inclined children, with the sole aim of determining the employed modalities by those studies. However there was a limit on available studies. Thus, the expansion of the study area will reveal modalities used in the related studies, coupled with probable additional modalities of potential investigations in the future by studies related with language comprehension skills of ASD-inclined children. Moreover, these findings also helped in highlighting the overall effectiveness level of MBIs, including how effective the motivation as well as learning of information is. Furthermore, this review presents some outcomes of the mobile intervention.

3.3.2.2 Search criteria

The search criteria for included studies of this review comprises two phases. 1) The first part is a substring that includes all autism related keywords, such as autism, autistic and ASD. 2) The second part consists of an additional sub-string of all related keywords as regards the methods, such as strategies, technology, digital storytelling, virtual, education, PECS, mobile, vocabulary, video, and images. Further, a sample search string that is based on the aforementioned expression is: (autism OR autistic OR ASD) AND (strategies OR technology OR digital storytelling OR virtual OR education OR PECS OR mobile OR vocabulary OR video OR images). The first phase of the search string would

reveal ASD related studies, whereas the second phase is to reveal MSIs studies for ASD, as well as intervention techniques employed. The search string was created manually for spate databases and journals, based on their respective functions. All these are treated as the process of learning and experimentation.

3.3.2.3 Inclusion criteria

The following criteria were used in determining the papers to be included for review: (1) the study directly answers at least one or more of this study's research questions; (2) is published in a peer-reviewed journal between 2000 and 2020; (3) is written in English.

3.3.2.4 Exclusion criteria

All unrelated papers that are not in line with the inclusion criteria and the vocabulary learning design and development, were excluded. Thus, focus of this study is on studies that are related to vocabulary learning field.

3.4 Problem identification and motivation

This step aims to understand the problem with the literature to be addressed during the research (Peffers et al., 2007). In this research, for identifying the problem, a systematic literature review of the strategies and MBIs being used to address reading deficits in children with ASD has been performed (refer to Section 2.4.1). The research problem being addressed in this study was identified via the exploring and review of existing studies. The research's problem statement has been explained at the introductory chapter of this study (refer to Section 1.2).

3.5 The objective of the solution

The main objective of this study is to find solutions for the identified problems (Section 3.4). In this research, the objective is to find new and effective learning instruction and design strategies and apply them to developing an interactive vocabulary builder model

for children with ASD. The new proposed model in this study will contain the components which are recommended by other researchers in this field.

The first identified problem is that most of the Autistic students do not receive sufficient instructions for learning vocabulary during childhood. Therefore, they have deficits in reading performances (Nally et al., 2018; Khowaja & Salim, 2013; Spector & Cavanaugh, 2015). Besides, most of the teachers who are responsible for delivering vocabulary builder instructions to the autistic children are not sufficiently skilled to teach vocabulary effectively (Ventura & John, 2009). According to (Nally et al., 2018), reading abilities in children with ASD is below the average rate and these children still need better and interactive learning instructions to build their vocabulary proficiently. Some studies suggest that lack of motivation and confidence, due to the effects of limited instruction, failure at school tasks and poor skills also affect vocabulary building and reading skills (Walker & Carta, 2019; Spector & Cavanaugh, 2015). These deficits cause them not just to delay in learning but also reduces their quality of life in society (Jackson, Hanline, & Whalon, 2020).

Thence, to address this problem, there is a need to have some educational strategic methods such as PECS and DS in the proposed model so that children can interact with the mobile-based intervention and also some graphics so they can get enough motivation to work with the intervention and learn vocabulary.

Difficulties in phonological processing of Autistic children have been noticed by researchers (Duff & Clarke, 2011; Millen et al., 2010; Martínez-Pedraza & Carter, 2009). Also, whole-word reading is a relative strength in these children (Solano, 2020). In a recent study on the analysis of mealtime behaviour problems and family stress in children with Autism Spectrum Disorders, which was published in 2016, the authors examined 53 children with ASD and 58 typically developing (TD) children ranging from 3–11 years

old. The result shows that high food selectivity has an association with mealtime behaviour problems for both groups, which caused nutritional problems in autistic children by not eating meals food due to inappropriate behaviours and failing to recognize healthy foods. The authors have noted that there is a need for interventions to reduce food selectivity, which may lead to decreases in mealtime behavioural problems (Curtin et al., 2016)

Comprehensively, a list of healthy foods (30 words) (Cermak et al., 2013) were chosen to address this autism problem for autistic children, so as to teach the words healthy foods to autistic children. Thus, while learning the words, the problem of eating meals in autistic children will also be resolved. This research makes use of English healthy food words in the proposed model so that Autistic children can learn and memorize these words easily.

To address the third identified problem in this study, there is a need to have a mobile-based intervention while students with ASD perform better when they deal with a mobile-based tutor compared to a human tutor (Conte, Ferreira, & Ramírez, 2020; Al-wakeel, Al-ghanim, Al-zeer, & Al-nafjan, 2015; Cerezo, Calderón, & Romero, 2019). Mobile-Based interventions are needed for early learning to address the barriers that children with ASD face when receiving vocabulary builder instructions (Azahari, Ahmad, Jamaludin, & Hashim, 2016). Researchers and practitioners have acknowledged the essentiality of vocabulary builder for improving comprehension in reading (Joseph et al., 2019; Luyster & Lord, 2011). Therefore, review studies specifically written on mobile applications for children with Autism Spectrum Disorder (ASD) knowing the significant influence of them on those children by (Griffith et al., 2020), was also found. They analysed diverse mobile application types of availability for ASD-inclined children. The results from this analysis show that MBI is being used extensively in providing additional skills of relativeness with ASD-inclined children; however there is a gap in studies and

applications of MBI in supporting preschool ASD-inclined children, in learning vocabulary (Xanthopoulou et al., 2019; Crespo & Martin, 2018).

Finally, to address the last identified problem in this study, there is a need to propose a new mobile-based intervention model for designing vocabulary learning for children with ASD. From the search on education vocabulary builder design framework for children with ASD, discoveries revealed that the design of educational software for autism-inclined children poses series of design challenges. There are few recommended guidelines alongside methodological procedures for designing technology for ASD-inclined children (Peffers et al., 2007). Literature search from that stage discovered few sources for general guidelines, yet with limit in relevance. An instance is the provision of 28 "teaching tips for autism-inclined children" (Grandin, 2002) of which some have some relevance in ICT, such as sudden sound loudness avoidance, where there is better performance in some, when there is a close proximity between the screen and the keyboard (Grandin, 2002). Most of the existing studies design educational vocabulary builder with limited aspects and simple steps. Limitations exist with regards to vocabulary builder software that is designed exceptionally for autism-inclined children (Pradibta & Wijaya, 2017; Khowaja & Salim, 2014). Therefore, a vocabulary builder design framework or model for autistic children is unavailable (Millen et al., 2010).

At the end of this step, Research Question 4 of this study is answered. Figure 3.4 shows how the proposed solutions address the identified problems.

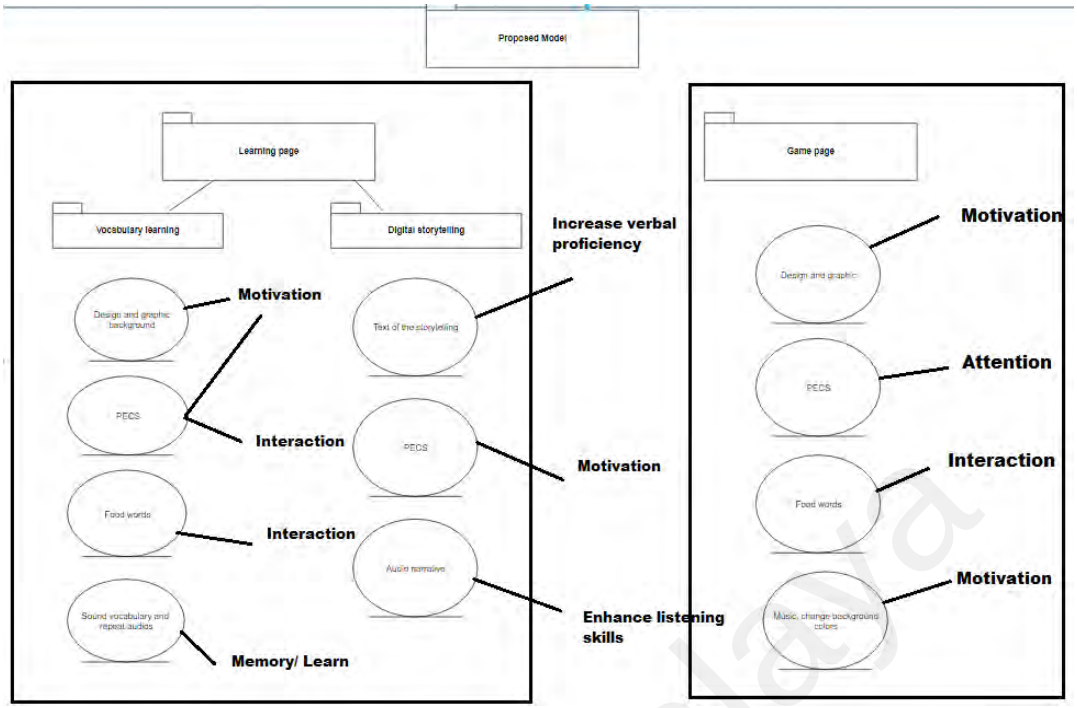

Figure 3.4: The Identified Problems and the Proposed Solutions

3.6 Design and Development

The purpose of this step is to use the findings (Section 3.5) for developing and designing an artifact. Different criteria that has significant role in the development of the performance of English vocabulary learning, were identified and they include, the Design Guidelines and Recommendations, design Interaction, Presentations, Navigation & Page Loading and Personalization. In this study, using the objectives (Section 3.5), a prototype is developed in the form of an Android Studio Mobile application with an interactive environment and equipped with PECS and DS together. This application is consisting of 2 phases, which are the learning phase and the practice or game phase for English vocabulary learning. Following the objectives (Section 3.5) and getting the idea from the review of the literature, led to a framework for the proposed new model's prototype. Figure 3.5 below shows the framework for the proposed model's prototype. Table 3.1 explains the number in each circle in Figure 3.5.

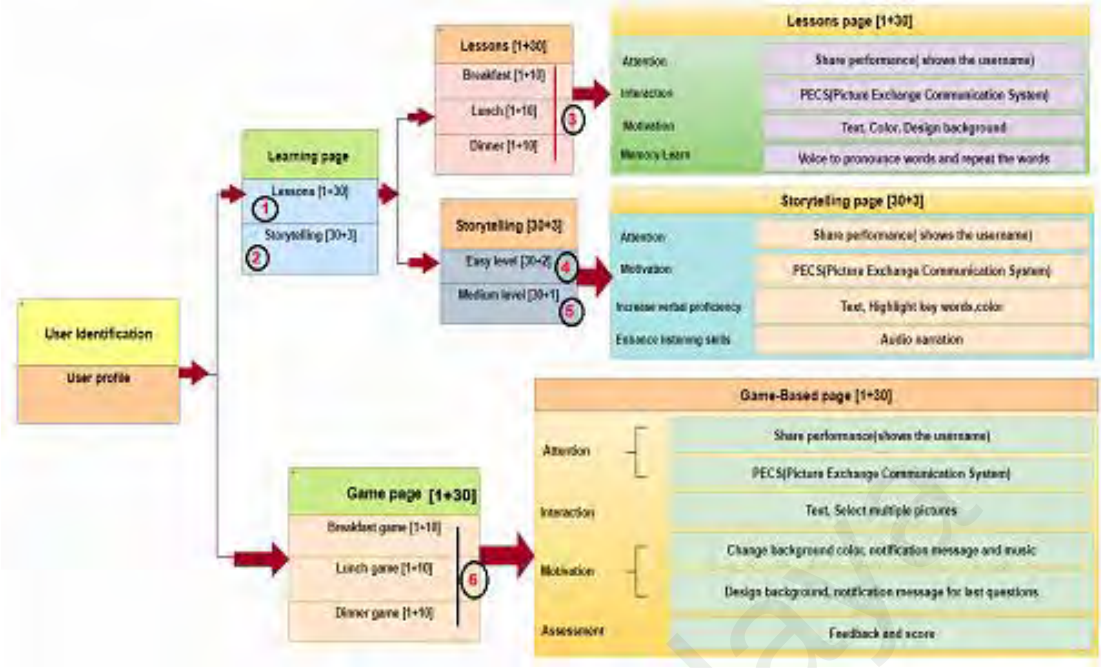

Figure 3.5: Proposed Framework to Design the Prototype

Table 3.1: 30 Words of Healthy Foods

NO	Explain
1	[1+30]: 1 to 30 words for learning page
2	[30+3]:1 to 30 words & 3 stories
3	[1+10]: each lesson has 1 to 10 words
4	[30+2]: 1 to 30 words & 2 stories for easy level of storytelling
5	[30+1]: 1 to 30 words & 1 stories for medium level of storytelling
6	[1+10]: each game level has 1 to 10 words

At the end of this step, the 3rd and 4th questions out of the 6 Research Questions are answered.

3.6.1 Design Guideline and Recommendations

People with Autism Spectrum Disorder have different preferences due to their different levels of disorder. One of the important components in the Mobile that should be considered when designing the mobile application for people with ASD, is the UI (User Interface) to be designed in a proper way (Pavlov, 2014). For designing a mobile application to people with ASD, the developers need to have feedback from the experts in the field, as well as from the real users of the mobile application which are individuals with ASD (Pradibta & Wijaya, 2017).

A basic guideline and methodology on how to prepare documents for people with learning disabilities was published by Department of Health (UK) and it presents the following rules (in this research, only 9 Rules were chosen, which were related to learning the Words) for preparing documents on the user interface:

Rule 1: Each model needs both pictures and words.

Rule 2: Make sure that it is clear as to which pictures support particular words of text.

Rule 3: Pictures must be clear to understand.

Rule 4: Pictures can be images, photographs, or other drawings.

Rule 5: Better to use big pictures, this helps more children to understand the information.

Rule 6: Each sentence must be as short as possible.

Rule 7: Words being used on a user interface should be easy to understand.

Rule 8: Words should be clearly written or printed.

Rule 9: Words have to be big enough to be seen easily (Pavlov, Mirchev, Gardjeva, & Rahnev, 2016; UK, 2009).

The authors in (Hess et al., 1998), also created a methodology for preparing documents for the people with learning disabilities and there are some extra recommendations suggested in this research paper as follows:

Each word should be in a separate line.

- Words should not be emphasized using Italic or Block capitals. For emphasizing, it is better to use Bold or underline styles.
- Inverted printing of the words should not be used. Using Dark words in a light background is easiest to read.
- The text size should be as large as possible.
- For boxes, pictures, and frames, it is recommended to use colours.
- A picture should not be used as a background for the text as it makes reading the word difficult.
- Illustrations used in the UI should be in a sharp focus.
- A picture should not be used as a background for the text as it makes reading the word difficult.
- Long words should not be hyphenated. All letters in a word should be together (Hess et al., 1998).

One of the methods that UI designers and Application developers rely on is using multimedia tools in an application for people with learning difficulties (Pavlov et al., 2016; Sofian et al., 2018). However, it should be noted that the use of rich multimedia tools will result in the weak performance of the application. In the work of Grynszpan, Martin, & Jacqueline, 2008, the authors carried out their research on 10 neuro-typical

children and 10 Autistic children. These children showed lower performance with the richer multimedia interfaces (Pavlov, 2014). It is recommended that the Multimedia tools used on UI for Autistic children should be as simple as possible because it will seem confusing to the children with ASD (Al-wakeel et al., 2015).

Due to the different needs and different personal preferences in children with ASD, one of the best and successful elements to be considered while designing interventions for them, is personalization (Pavlov et al., 2016). The benefits and importance of personalization are also confirmed in literature (Sofian et al., 2018). For designing the UI, recommendations in guidelines have been followed which was set forth by the W3C (World Wide Web Consortium) (Pavlov, 2014). Following that guideline, these are the recommendations for designing an appropriate UI for Autistic individuals: (Pavlov, 2014).

3.6.2 Interaction

For having a better interaction between the MBI and the user, the following list of required items and the items which are to be avoided are recommended thus:

Required:

- The buttons on the UI should be large and clear.
- Short instructions (Tooltips) should be given in each step.
- Design as simple as possible. Few components should be on the screen.

To be avoided:

- Multi-coloured icons.
- Cluttered and crowded interface.

- Buttons with Icon only. Except for the most popular buttons (like Back, Exit, etc.).

3.6.3 Presentations

To have a good presentation of the document to the users, the below list of required and non-required items is recommended:

Required:

- Clear and understandable fonts should be used for the words.
- Simple graphics should be used on the UI.
- Words should be presented in a single column.
- Textboxes should be separated from the rest of the elements on the UI.
- Soft and mild colours should be used.
- A proper contrast should be used between the background and the font.

To be avoided:

- Use of bright colours
- Background images for the text.
- Horizontal scrolling on the UI.

3.6.4 Navigation and Page Loading

To have useful navigation and fast loading of the pages, the below list of required and non-required items is recommended:

Required:

- The navigation should be clear and simple.
- Mouse or keyboard should support navigation.

- Buttons should be used.
- The loading of pages should be fast.

To be avoided:

- Use of complex menus and functions.

3.6.5 Personalization

Finally, to personalize the document presented to each of the users, the following items should be available to be changed by the users.

- Font size and font type.
- Loading of animations and visual elements (Pavlov, 2014).

3.7 Demonstration

The main aim of this stage is to demonstrate the usability of the artifact that has been designed and developed in the previous stage (Peffers et al., 2007). In this study, this stage requires some users to use the artifact and ensure the usability of the prototype before it is used by the Audience (in this case, Autistic children). To do this, the researcher installed the developed Mobile application on one of her personal Mobile in Zahra's Flowers pre-school and requested 4 students to use it. They noticed some runtime errors while using the prototype and reported it to the authors which were then solved and rebuilt.

The prototype was developed using JAVA programming language on Android Studio 2019 environment. The software application is developed by using the Android SDK (Software Development Kit), which is a set of development tools used in developing applications for the Android platform, the Android JDK (Java Development Kit), which

includes the required libraries, debugger, an emulator, APIs (Android Application Program Interfaces), etc.

3.8 Evaluation

This stage represents the evaluation of the prototype to ensure the effectiveness of the prototype for the purpose it was developed (Peffers et al., 2007). Due to the prototype in this study being a model which includes PECS and storytelling together methods, text, audio narrative technology, and game together, for evaluating the prototype, the researcher made use of a combination of methods and techniques proposed in literature (Novack et al., 2019; Bosseler & Massaro, 2003).

In this research, the author first chose 10 autistic students from a group of 30 autistic students in a preschool in Shiraz, Iran. The selection criteria for choosing the autistic children were as follows:

1. Autistic students must be between 5 and 6 years old. (13 students who were above 6 were excluded).
2. Autistic students usually have deficits in English vocabulary learning. (4 students were excluded because they do not have many difficulties).
3. Autistic students must have basic knowledge of using a Mobile. (3 students were excluded).

Among them, 10 students were chosen from the Zahra's Flowers pre-school in Iran. For the experiment, the researcher randomly divided them into two groups of five. Consideration was given to the first group of students as the experimental group of this research and the second group of students as the control group.

An experimental evaluation of the prototype was performed with the real users at Zahra's Flowers pre-school to ensure the effectiveness and usability aspect of the

developed prototype. In the first group, the prototype was installed to the mobiles and the students were allowed to use the prototype. There was a need to compare the proposed model with an existing traditional method of word learning with PECS-based cards and storytelling books intervention for autistic children. Thus, in the second group, the researcher chose training in the classroom with the traditional method of health-word learning Intervention, which is proposed and developed by Bondy. and is explained in literature (Bondy, 2017).

PECS-based cards is a cards-based image intervention which is used to teach word learning to autistic student. This program has used cards for word presentation (Bondy, 2017). The control group (second group) of this study were using this program in the classroom for learning health word during the prototype experiment sessions.

At the end of the experimental evaluation of the prototype with real users at the Zahra's Flowers preschool, a questionnaire-based survey was conducted to evaluate the effectiveness and usability aspect of the developed prototype performance.

The evaluation part in this step answers the 5th research question of this study.

3.9 Communication

This is the final stage of this methodology, which represents the findings to the community (Peffers et al., 2007). At the end of this study, the findings of this research and the result of the prototype evaluation is hereby represented in the form of a dissertation.

The evaluation part in this step answers the 6th question, which was the last in the study's research questions.

3.10 Summary

The research methodology used in conduct of this study has been discussed amicably in this chapter. The research methodology consists of seven main steps. Each step and sub-step have been discussed and justified to explain the process used in conducting this research.

The next chapter discusses the proposed model for designing a vocabulary learning for autistic children.

CHAPTER 4: PROPOSED MODEL

4.1 Introduction

Thus, chapter describes the proposed model used in solving the research problem, as highlighted in Chapter one. It further introduces the new proposed model in this study, describes the design and develops a prototype. The components used in the 2 phases of the model and the UI design rules and recommendations have also been discussed. The screenshots of the developed prototype in this study are also provided. In this chapter, the completion of the second and third research objectives has been achieved. It is followed by the development of a Mobile-Based model for English vocabulary building using appropriate vocabulary building instructions development for autistic kids, and to develop a prototype of the model.

The subsequent sections give a comprehensive description of each phase of the proposed model with details. The chapter ends with a summary in Section 4.6.

As discussed previously in the review of the literature, Mobile-Based Interventions (MBIs) have been used to address different difficulties in kids with ASD and most of them have been effective enough for the purposes they have been developed for. So, the proposed model in this research is a MBI, used to address the English vocabulary learning deficits of children with autism. For learning aims, kids with autism mostly lack attention, motivation, verbal proficiency, listening skills, and interaction that results in learning disabilities among this group. The focus of this game is to address the attention, motivation, verbal proficiency, listening skills and interaction deficits of autistic kids and that will help them to learn English vocabulary. In addition to this, PECS and DS, alongside other capabilities like (text, voice, color) have been used in our proposed model, which is believed to help this group improve their interaction with the MBI.

4.2 Design of the proposed Model

As long as this model is made for autistic children and they are not comfortable with complex menus, functions and a large number of buttons in one page (Khowaja & Salim, 2014; Tornblad, Jones, & Inan, 2019; Tornblad et al., 2019), the researcher decided to develop the model in 2 phases. This helps to avoid the complexity of the learning intervention and having a simple and understandable user interface for this population. Figure 4.1 shows the major components of the proposed model.

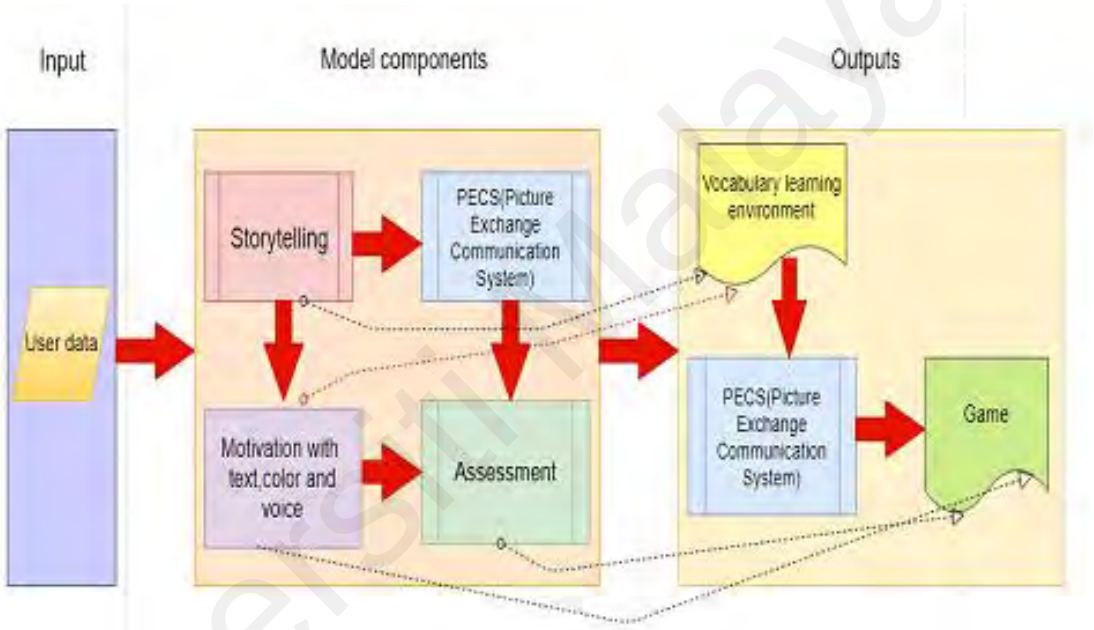

Figure 4.1: Design Components of the Proposed Model

4.2.1 Design of the learning phase (1st phase)

The first phase of this research's proposed model is the learning phase in which the users learn words that has 2 parts. In the first part of this stage, PECS has been used and it helps autistic children in learning and pronouncing the words with pictures, voices, and text. In the second part of this phase, digital storytelling with audio, pictures, text has been used and it helps autistic children in learning, verbal proficiency, and listening skills, as the words come with the symbolic presentation of storytelling. The components in this phase have been designed and put together so that they can address the main vocabulary

learning deficits in kids with autism. Detailed information about the components can be found under the “components” title.

4.2.1.1 Components of the learning phase (1st phase)

- PECS (Picture Exchange Communication System)

PECS is an important method for learning vocabulary, especially for autistic kids because this method helps them to learn vocabulary with pictures, thus enabling they have a better understanding of the vocabulary learning and being able to retain it in their memory. Based on the current study’s aim, the PECS method was employed for vocabulary learning intervention, because it is the best choice, as suggested by literature. PECS start-up with regards to training one’s vocabulary demands a means of using different images for specific purposes (Travis & Geiger, 2010; Bondy, 2017).

Furthermore, from the findings of some scholars who addressed the attention deficits of autistic children, the use of Multimedia components was identified as an effective tool (Watson, Flippin, & Reszka, 2010; Jurgens, Anderson, & Moore, 2014). Therefore, this research used some of the Multimedia components in its’ model, such as images to gain the children’s attention; also, the PECS method was employed in the vocabulary learning phase of the proposed model's prototype. This component helps to increase attention and motivation in children with autism vocabulary learning deficits and keeps them interacting with the mobile device.

- Healthy food 30 words

In the second element of this phase, this research used 30 words of healthy foods that encourage kids with autism to undergo vocabulary learning. Efforts were made to choose simple words about healthy foods (Miyajima, Tateyama, Hirao, Nakaoka, & Higaki, 2014).

- Digital Storytelling

In the third element of this phase, digital storytelling was employed, which is an important part of the learning stage, thus split into 2 levels, each level has story text with audio narrative and PECS. For each sentence, a picture of the sentences was input. This part of the learning page design helps in improving listening skills and verbal communication.

- Sound vocabulary

This is the fourth element of this phase, here there is an audio button which lets the users listen to the word's pronunciation. Each pronunciation is designed for each picture. This button has been used in this phase to address the memory deficits of children with autism.

- Next and Previous Buttons

There are two buttons in this phase, which are used to switch the existing word to the next word or a previous word. As long as there are 30 healthy food words used in this phase, the words are represented to the user one by one and each word is pronounced by the audio button. If the user could learn to learn the word in once, they can go to the next word by pressing the Next Button, and if they could not learn the word in one goal, they can press the repeat button to listen to the word again.

- Progress Bar

The sixth element in this phase is the progress bar, which shows the learning progress of autistic children. This element helps them know how many words they have learned so far and satisfies them with their progress. One of the best ways to satisfy the MBI users while using it for learning purposes is to keep them aware of their current progress (Khowaja & Salim, 2013).

- Repeat Button

There is a repeat button in the learning phase, which lets the users listen to the word as many times as they want. Pressing this button will let the sound read the word again and again so that it helps the user in memorizing the word's pronunciation. In short, this button has been used in this phase to address the Memory (Memorization) deficits of the autistic children.

4.2.2 Design of the practice phase or puzzle game (2nd phase)

The second phase in this model is the puzzle game phase in which the users can practice what they have learned earlier in the learning phase. This phase has been designed as a puzzle game to encourage autistic children in using it. In this phase, the users will see a "Please click the apple" at the top of the picture from the list of words that they have already learned in the learning phase. They will be touching the correct picture according to the corresponding word.

If the user could select the correct picture of the word accurately, they will get one score in the scores section and the word will be changed to the next word in the list. In case of incorrect selection, the user will get a negative feedback, the components used in this phase are described under the components sub-section below.

4.2.2.1 Components of the Practice phase (2nd phase)

- PECS

This element in this phase is multiple-choice, it has been used to address the attention deficits of autistic children. This phase is a game-based phase.

- Score Section

The score section is used in this phase to provide the user with feedback about their word learning and motivate the user to learn the words. Assessment of learning

performance in autistic children is the best way of motivating them in learning and other literacy programs.

- Start Game Button

When the user enters the practice page, they will see the very first word of the words-list in the page. They need to press the (Start Game) in order to start practicing the word reading. This button is used to help the user start reading a word whenever they are ready for it.

4.3 User Profile

This proposed model requires a login of the user to get access to the user profile. If a user uses this model for the first time, they need to register themselves to the system. Once they are registered to the system, next time they would be able to login as they will be recognized by the system with the username; also, the system shares the username on all pages of the platform to give motivation and attention to help children with autism to learn better. As this system deals with autistic children, of which they lack the ability to be comfortable with the crowded tools in a system, the registration has been designed in a very simple and easy way, so that it can be usable by this population. For registration, the children need to type a username and password to register themselves as valid user(s).

In this model, the words are labelled with a number, which is the index of the array in which the words have been stored. In the design of the model, 30 food words were designed and used, for each word a picture and a voice pronunciation was used for teaching, and these were used in 3 arrays of Wordlist []. The wordlist array stores each word with an index and this index is used to recognize the picture and voice pronunciation of each word when the user makes a touch while using the system. For example, the word “Butter” is the 3rd word in the word list, and it is stored with an index of 2 as Wordlist [2]. So, if a child reaches the word “Butter” in the learning phase, the index for this word

which is 2, for displaying to the specific user, will refer the same index of picture and voice pronunciation of this word.

The aforementioned is similar in the game phase, if a user starts practicing the words until the final stage of the game. After finishing each part of the game, on the last page the system will show the assessment on the performance of each specific user according to the score, with the username and a motivational message. Besides, there is another variable in the practice phase which is the list of the skipped words during the practice. If a user could not recognize a correct word, the system will reduce 1 mark from the total scores of the user. In this stage, the user doesn't have time limitations for recognizing and choosing the correct words. The user can without any stress choose the correct word and for this action of the user, the system will add 1 mark to the total scores and show the motivational message on the page with a change of the background to a green colour, as well as play an assigned music. After recognizing and choosing the word on the game page, the system automatically moves to the next stage, and will be presented on the screen.

4.4 30 healthy food words

In a recent study on the analysis of mealtime behaviour problems and family stress in children with Autism Spectrum Disorders, which was published in 2016, the authors examined 53 children with ASD and 58 typically developing (TD) children ages 3–11 years. The result shows that there was an association between mealtime behavioural issues and high food selectivity for both groups, which has caused nutritional problems in autistic children by not eating meals/food due to inappropriate behaviours and failing to recognize healthy foods. The authors have noted that there is need for interventions in reducing issues of food selectivity, which might result in a reduction of problems associated with mealtime behaviour (Curtin et al., 2016)

So, the researcher chose a list of healthy foods (30 words) (Cermak et al., 2013) to address this autism problem for autistic children, as well as to teach healthy foods related words to autistic children. Thus, while learning the words, the problem of eating meals in autistic children will also be resolved. Thence, the research used English healthy food words in the proposed model, so that autistic children can learn and memorize these words easily. The 30 healthy food words list has been used in this model as a database of words. These are the most commonly used nouns and are easy to be learnt by the children. These words were selected for this model to help autistic children in learning whole-word reading.

The 30 words of the healthy food list, which has been used in the current model, is shown in Table 4.1.

Table 4.1: 30 Words of Healthy Foods

NO	Breakfast words	NO	Lunch words	NO	Dinner words
1	Boiling egg	11	Chicken	21	Almonds
2	Butter	12	Fish	22	Apple
3	Cheese	13	Juice	23	Banana
4	Chocolate	14	Meat kebabs	24	Fruit salad
5	Fry egg	15	Noodles	25	Olive
6	Honey	16	Pita bread	26	Pizza
7	Jam	17	Rice	27	Sandwich
8	Milk	18	Salad	28	Soup
9	Pancake	19	Shrimp	29	Walnut
10	Toast bread	20	Spaghetti	30	Yogurt

4.5 Design Implementation & Development of prototype

To design a better prototype for autistic children, there was a need to consider all the earlier discussed recommendations in this chapter's section 4.2 and research methodology

in chapter 3. Since the autistic children are not comfortable with lots of tools and buttons in the application, the researcher tried to design the prototype as simple as possible. To avoid confusion amongst children, the prototype was divided into two separate stages, which are learning stage and practice stage. This design document is used in transforming the design into a prototype. The development of the prototype is discussed in the next sections.

To personalize the model for each user, it is first necessary for each user to register on the application for the first time with a simple username and password, then for the next time, each user only needs to login to the application by entering the already registered username and password.

4.5.1 Tools used

This section presents the tools used in developing the prototype.

4.5.1.1 Android

Android is an operating system that is currently widely used in smartphones or cell phones, which have the architecture its own platform. This research employed the Android SDK (Software Development Kit) to develop the prototype. In the Android platform, the prototype was designed in the two layers e.g., 1) Application Framework and 2) Android & Runtime Libraries.

(a) ***Java Language***

Java is a programming language that has been used in this research in developing a prototype which can be compiled, deployed and run on a mobile's screen, and on embedded environments. The huge Java library proffers an extensive range of facilities, including rich performance, user interface, portability, security features, and user interface, of which are of utmost necessity in contemporary applications.

(b) ***Implementation of the database***

For this application, SQLite database was used to store all data. SQLite is a database of the Android device.

4.5.2 User Interface of the prototype

This sub-section presents the details of the entire prototype screens.

4.5.2.1 Splash page

This page is the beginning page from which one can run the application. Figure 4.2 below is the first page, the login page, and the registration page after starting the application.

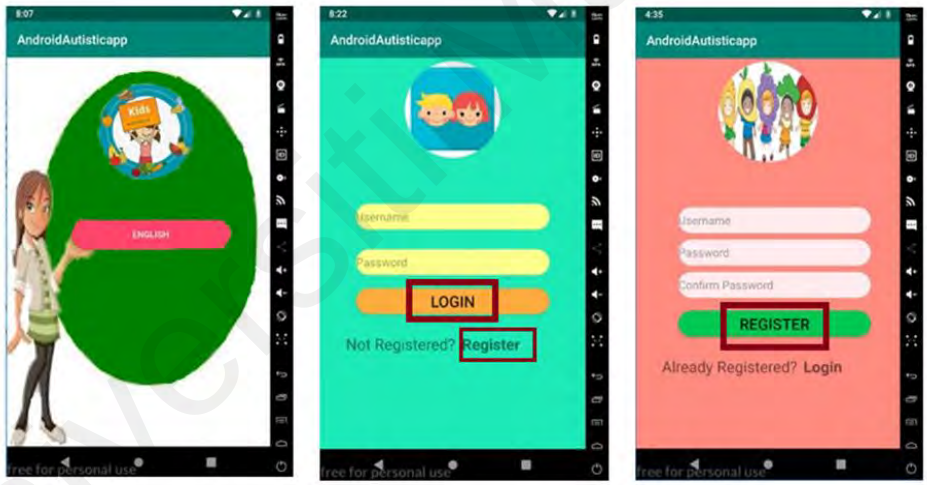

Figure 4.2: Splash Page, Login and Register Pages of the Developed Prototype

4.5.2.2 Registration page

For the first time, the user need to register with their username and password on the registation page. To do this, they will touch on the 'Register' button and the user would be directed to the registration page. After registration, the username and password will be saved. When the registration is successful, the screen shows a 'Successfully Registered'

message. Subsequently, when the users use the application, they can just touch login to the application with their username and password. Figure 4.3 shows the registration page.

Figure 4.3: Registration Page for First-Time Users

4.5.2.3 Login page & Main page

In the login page, if the user enters an incorrect username or password, the system will show a 'Username or Password does not match' message on the screen. After login into the application, the user will see a welcome message from the application and the user will see the main page of the application. They need to choose between the two stages of the application, Lessons (learning) stage or Game stage. Figure 4.4 below shows the login page.

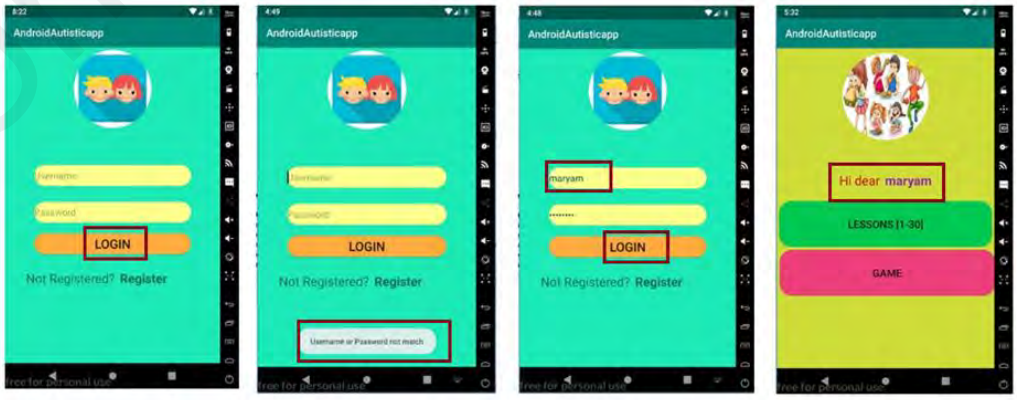

Figure 4.4: Login Page and Main Page

4.5.2.4 Learning page

If the user chooses the learning stage (Lessons) from the above page, a new page for learning words will be opened to the specific user. The user will see the two stages of learning, Lesson menu, and Storytelling. The lesson menu has three stages, Breakfast, Lunch and Dinner, of which each lesson has ten lessons. The storytelling has two stages, Easy and Medium level, thus resuling to a total of three levels in this stage. If the users choose breakfast lesson or lunch lesson or dinner lesson and move to the next page, they learn words one by one. In this page, PECS has been used to show each word with their pictures and their pronunciation. Figure 4.5 shows the learning stages (Breakfast and Lunch Lesson).

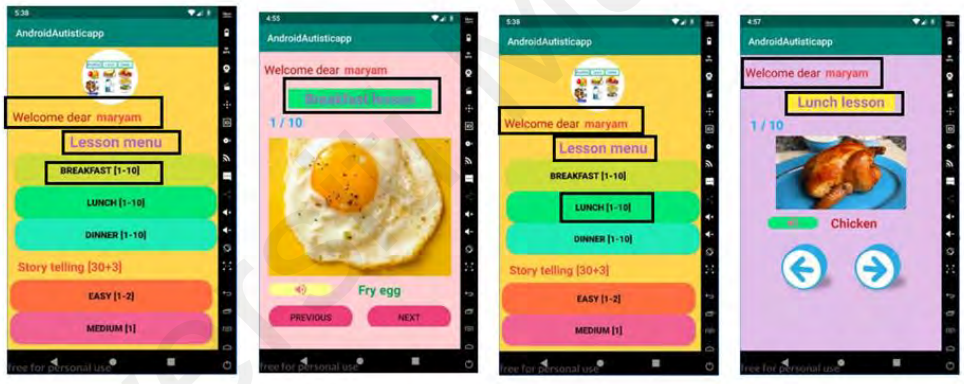

Figure 4.5: Learning Page - Breakfast & Lunch Lessons

In the learning stage above (Breakfast Lesson), the 'Next' button and 'Previous' button are to change the word to the next word or to the previous word. At the top of the page, it shows the welcome message with the name of the specific user. It shows the order of the word from a total of 30 words in the queue. Below the page in the middle and beside the text of the word, the pronunciation button is to let the user listen to the words as many times as they need it. The last element on this page is the top of the page and under the title, the counter shows the number of words.

Next, the specific user chooses the dinner's stage of the lesson menu on the learning page. This stage has ten lessons. They learn words one by one. In this page, PECS has been used to show each word with their pictures and their pronunciation. The second stage of the learning page is 'Storytelling', comprising two parts 'Easy level' and 'Medium level'. The easy level has two stages of the story and the medium level has any stage of the story. According to the below figure, if the specific user chooses the easy level of the storytelling, then the easy storytelling page will be shown. They learn building words in the sentences (storytelling), encourage eating healthy foods, learn words one by one with colorful sentences of the story. Also, they learn pronunciations of words with the audio narrative. In this page, PECS has been used to show the picture of each word in the sentences of the story, text to show the stories and their pronunciation with the audio narrative. Figure 4.6 shows the learning stages (Dinner lesson and Easy level of the Storytelling).

Figure 4.6: Learning and Storytelling Pages

In the learning stage of the dinner lesson above, the 'Next' button and 'Previous' button are to change the word to the next word or to the previous word. At the top of the page, it shows the welcome message with the username of the specific user. It shows the order of the word from a total of 30 words in the queue. Below the page in the middle and beside the text of the word, the pronunciation button is to let the user listen to the words

as many times as they need it. The last element on this page is the top of the page and under the title, the counter shows the number of words. In the easy levels of the storytelling stage above, at the top of this page is a title to show the level of storytelling stages. Under the title and left side, it shows the welcome message with the username of the specific user. The next button and previous button are to change the next level or go to the previous level. Below the welcome message and left side, it shows the texts of the story, each sentence has different colours to give more motivation to students. The front side of each sentence has a picture to show the word. Below the last pictures and in the middle of the page, the audio narrative button helps to let the user listen to the stories as many times as they need it.

4.5.2.5 Digital Storytelling page

In the learning stages, the last parts of the 'Storytelling' stage is the medium level, if the specific user chooses the medium level of the storytelling, then the medium storytelling page will be shown. They learn building words in the sentences (storytelling), encourage eating healthy foods, learn words one by one with colourful sentences of the story and give more attention to important sentences by highlighting the healthy foods. Also, they learn pronunciations of words with the audio narrative. In this page, PECS has been used to show the picture of each word in the sentences of the story, text to show the stories and their pronunciation with the audio narrative. The introduction of the learning process is over. Now, the introduction of the game can start. If the user chooses the game, then the game stages will open to the user. The game menu has three stages, Breakfast game, Lunch game, and Dinner game, of which each game has ten stages. Figure 4.7 shows the learning stages 'Medium level of the storytelling', first page and the 'Game Menu' page.

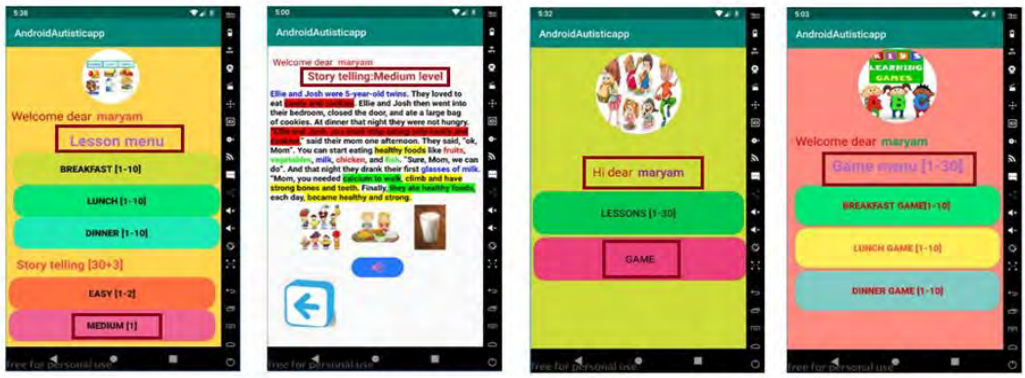

Figure 4.7: Digital Storytelling and Game Pages

In the medium level of the storytelling stages above, at the top of this page and left side, it shows the welcome message with the username of the specific user. Under the welcome message is a title to show the level of storytelling stages. The previous button is back to the lesson menu page. Below the title and left side, it shows the texts of the story, important sentences and words, having different colours and highlights to give more motivation and attention to learning food's vocabulary. Below the story's text are 3 pictures that show the picture of each word. Afterwards, below the pictures and in the middle of the page, the audio narrative button is to let the user listen to the stories as many times as they need it.

4.5.2.6 Game page

If the user chooses the game stages, then the game menu page will open to the user. This 'Game Menu' page has three stages: 'Breakfast game', 'Lunch game', and 'Dinner game', of which each game has ten stages. In this page, PECS has been used to show the pictures of a word in 'Multiple-Choice' in the game, 'Text' to show the question, 'Notifications Message', 'Change Background Colours' to red or green, 'Music' and 'Score'. At the end of the game, the system will show the 'Assessment' of specific users with motivational messages. If the specific user chooses the breakfast game, then the

breakfast game will open to the specific user. Figure 4.8 shows the game stages and the breakfast game.

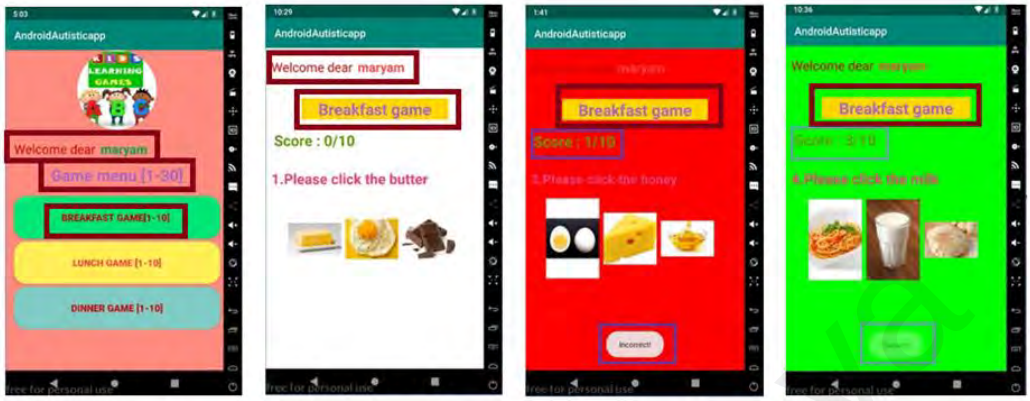

Figure 4.8: Game Page and Breakfast Game

In the breakfast game stage above, at the top of this page and left side, it shows the welcome message with the username of the specific user. Under the welcome message is a title to show the game according to stages. Under the title, the 'Score Section' shows the number of words based on how many times the user selects the correct picture, and another number is the total stages of the game. The middle page is a text to help the user click or select the food's word which matches the picture. The last part is a picture multiple choice, comprising three pictures, but the user must select only one correct picture. After the user selects the picture for answering, the system automatically changes the word and pictures multiple choice. According to the breakfast game stage above, the specific user selects the correct picture that matches with the food's word, then the system automatically shows some actions at the same time as adding one score, change background colour to green, show the correct message, and start playing the correct music to give motivation, attention and encourage the specific user. For another stage, the specific user selects the incorrect picture that doesn't match with the food's word then the system automatically shows some actions at the same time such as: don't add one score, change background colour to red, show the incorrect message and start playing the music

to enable the user understand that the selection is not correct, as well as help provide more attention and encourage the specific user to make another selection.

4.5.2.7 Assessment page

In the last stages of the game and before the game gets over, the system shows the notification message such as “It was the last question”. After the breakfast game is over, the system automatically shows the assessment page. The assessment page is the feedback of the specific users on their breakfast game. This page shows the user’s score with motivational messages to encourage more practice if the user’s score is less than five of ten stages for each game. The system shows the assessment page with the blue colour background to give motivational messages if the user’s score is less than five. The system shows the’ Assessment’ page with a green colour background to give more motivational messages if the user’s score is more than five. If the specific user chooses the lunch game of the ‘Game Menu’ page, then the lunch game will open to the specific user. Figure 4.9 shows the ‘Assessment’ page of the ‘Breakfast Game’ and ‘Lunch Game’.

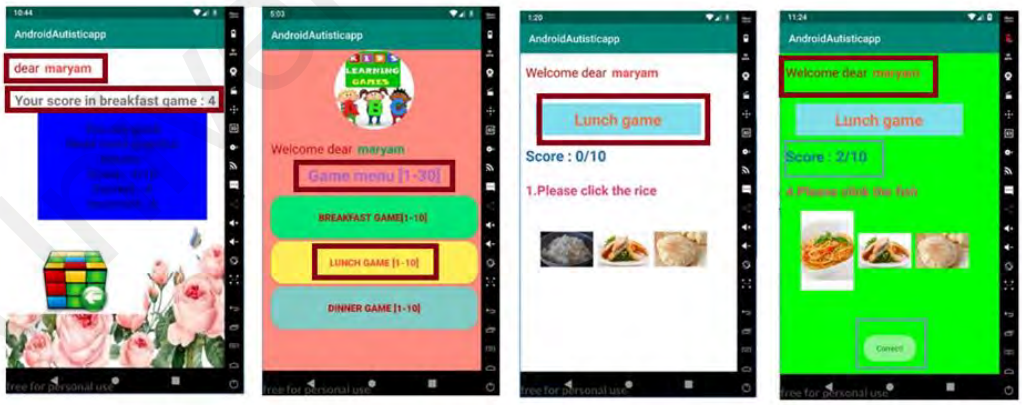

Figure 4.9: Assessment Page and Lunch Game Page

In the ‘Assessment’ page of the ‘Breakfast Game’ stage above, at the top of this page and left side, it shows the dear message with the username of the specific user. Under the dear message is a title to show the ‘game score’ of the specific user. Under the score, in

the blue square is the details of the user's score which includes: a motivational message, total score, number of correct answers and number of incorrect answers. This assessment is in the blue square because the score is less than five. The last part of this page is a back button, of which when the users click this button, they will be back to the 'Game Menu' page. In the 'Lunch Game' stage above, at the top of this page and left side, it shows the welcome message with the username of the specific user. Under the welcome message is a title to show the game stages. Under the title, the 'Score Section' shows the number of words at which the user selects the correct picture, and the other number is the total stages of the game. The middle page is a text to help the user click or select the food's word that matches the picture. The last part is a picture multiple choice, wherein there are three pictures, but the user must select only one correct picture. After the user selects the picture for answering, the system automatically will change the word and pictures multiple choice. According to the 'Lunch Game' stage above, the specific user selects the correct picture that matches with the food's word, after which the system automatically shows some actions at the same time such as adding one score, change background colour to green, show the correct message, and start playing correct music to give motivation, attention and encourage the specific user.

In the 'Lunch Game' stage below, when the specific user selects the incorrect picture that don't match with the word, the system automatically changes the background to red colour. In the last stages of the game and before the game will be over, the system shows the notification message of "It was the last question". After the lunch game is over, the system automatically shows the assessment page. The assessment page is the feedback to the specific users of their lunch game. This page shows the user's score with motivational messages to encourage more practice if the user's score is less than 5 of 10 stages for each game. The system shows the assessment page with the green colour background to give more motivational messages if the user's score is more than five. If the specific user

chooses the dinner game of the game menu page, then the dinner game will open to the specific user, this stage is the last stage of the game. Figure 4.10 shows the 'Assessment' page of the Lunch game and Dinner game.

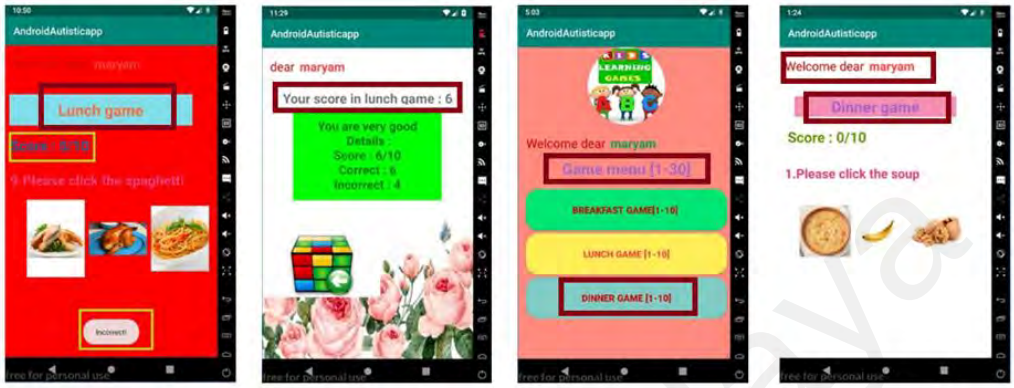

Figure 4.10: Assessment Page and Dinner Game Stage

According to the lunch game stage above, if the specific user selects the incorrect picture that don't match with the food's word, then the system automatically shows some actions at the same time like: don't add one score, change background colour to red, show the incorrect message, and start playing incorrect music to give notification for the need to be more motivated, attentive and encourages the specific user. In the assessment page of the lunch game stage above, at the top of this page and left side, it shows the dear message with the username of the specific user. Under the dear message is a title to show the "Game Score" of the specific user. Under the score, in the green square is the details of the user's score like a motivational message, total score, number of correct answers and number of incorrect answers. This assessment is in the green square because the score is more than 5 of 10 (total scores in this stage). The last part of this page is a back button when the users click this button, they will be back to the game menu page. In the dinner game stage above, at the top of this page and left side, it shows the welcome message with the username of the specific user. Under the welcome message is a title to show the game of stages. Under the title, the 'Score Section' shows the number of words that the

user selects the correct picture, and the other number is total stages of the game. The middle page is a text to help the user click or select the food's word that matches the picture. The last part is picture multiple choice comprising three pictures, but the user must select only one correct picture. After the user selects the picture for answering, the system automatically will change the word and picture multiple choices.

In the dinner game stage below, when the specific user selects the correct picture match with the word, the system automatically changes the background to green colour. If the specific user selects an incorrect picture that don't match with the word, the system automatically changes the background to blue colour. In the last stages of the game and before the game will be over, the system shows the notification message of "It was the last question". After the dinner game is over, the system automatically shows the assessment page. The assessment page is the feedback to the specific users of their dinner game. This page shows the user's score with motivational messages to encourage more practice and is displayed in the blue square if the user's score is less than five of total scores (10) and for user's score that is more than five of total score (10), the system shows the assessment page in the green square to give more motivational messages. Figure 4.11 shows the 'Assessment' page of the Dinner Game and Dinner Game with green and red backgrounds.

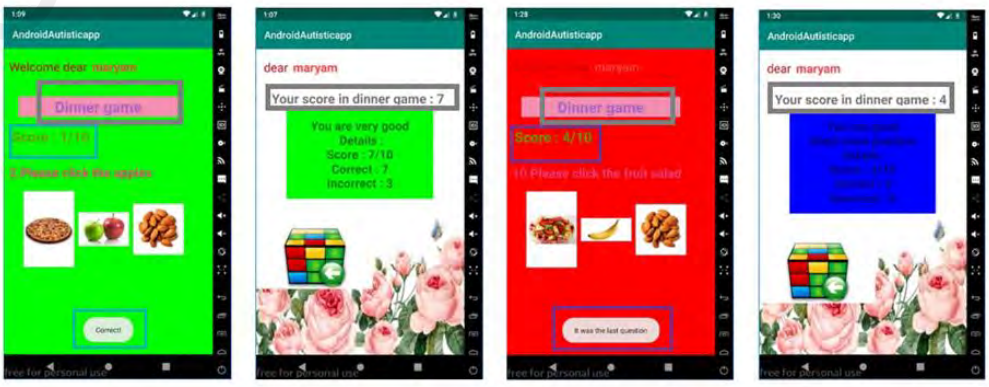

Figure 4.11: Assessment and Dinner Game Pages

According to the dinner game stage above, we show two kinds of action's system when the user selects the correct or incorrect picture in the game. In the lunch game stage above, if the specific user selects the correct picture that matches with the food's word, then the system automatically shows some actions at the same time such as: adding one score, change background colour to green, show the correct message, and start playing the correct music to give motivation, attention and encourage the specific user. At the top of this page and left side, it shows the welcome message with the username of the specific user. Under the welcome message is a title to show the game stages. Under the title, the 'Score Section' shows the number of words that the user selects the correct picture, and another number is the total stages of the game. The middle page is a text to help the user click or select the food's word that matches the picture. The last part is the picture multiple choice comprising three pictures, but the user must select only one correct picture. After the user selects the picture for answering, the system automatically will change the word and picture multiple choices.

In the assessment page of the dinner game stage above, at the top of this page and left side, it shows the dear message with the username of the specific user. Under the dear message is a title to show the 'Game Score' of the specific user. Under the score, in the green square is details of the user's score like a motivational message, total score, number of correct answers and number of incorrect answers. This assessment is in the green square because the score is more than five of ten (total scores in this stage). The last part of this page is a back button of which when the users click this button, they will be back to the game menu page. If the specific user selects the incorrect picture of the dinner game stage above, that don't match with the food's word, then the system automatically shows some actions at the same time like don't add one score, change background colour to red, show the incorrect message, and start playing incorrect music to give notification so as to indicate the need for more motivation, attention and encourage the specific user. At the

top of this page and left side, it shows the welcome message with the username of the specific user. Under the welcome message is a title to show the game stages. Under the title, the 'Score Section' shows the number of words that the user selects for the correct picture, and the other number is the total stages of the game. The middle page is a text to help the user click or select the food's word that matches the picture. The last part is picture multiple choice comprising three pictures, but the user must select only one correct picture. The bottom of the dinner game stage above, with the red background, is the last page of the game stage, which shows the notification message and is in the last stages of the game and before the game is over, the system shows the notification message of "It was the last question". After this, the dinner game is over, the system automatically shows the assessment page. In the assessment page of the dinner game stage above, at the top of this page and left side, it shows the dear message with the username of the specific user. Under the dear message is a title to show the ''Game Score'' of the specific user. Under the score, in the blue square is the details of the user's score like a motivational message, total score, number of correct answers and number of incorrect answers. This assessment is in the blue square because the score is less than five. The last part of this page is a 'Back Button' of which when the users click this button, they will get back to the game menu page.

4.6 Summary

This chapter gave an explanation of the proposed model in this study. It also described the design of the components of the proposed model in 2 phases of the model and the UI design rules as well as recommendations have also been discussed. After the design as explained in the components section, each phase were broken-down into steps, thus providing further descriptions on the prototype design process for each phase. This process model can be used as a general step-by-step process to assist the development implementation for designing a prototype.

The screenshots of the developed prototype in this study are also provided. This chapter completes the second and third research objectives of this research.

The next chapter will discuss the evaluation of the effectiveness and usability of the Mobile-Based English vocabulary learning prototype.

CHAPTER 5: EVALUATION

5.1 Introduction

This chapter presents the final result of the fourth objective in this research. It is followed by the evaluation of the effectiveness and usability of the Mobile-Based English vocabulary learning prototype for the improvement of learning vocabulary performance among autism inclined children, also the findings from evaluations are discussed.

5.2 Evaluation Metrics

To evaluate performance and effectiveness of a software system, the researcher used a combination of software quality evaluation methods proposed in literature (Barkmann, Lincke, & Löwe, 2009; Comer, Garrido, Geissler, & Colin, 1998; Jeanrenaud & Romanazzi, 1994). In this method, for data collection and application of the proposed model prototype, Mobile-Based Vocabulary learning (MBVL), the researcher evaluated performances of the participants with pre-test and post-test in two groups, first group of the users used the proposed model's prototype and second group used training in the classroom; at the end of this experience, comparison was made on the result of the two group of users. Consequently, a survey was conducted after the application prototype had been tested, this was done for the collection of feedbacks, so as to know the effectiveness and usability of the application. The survey data and the results are presented and discussed to evaluate the performance effectiveness and usability of applying MBVL. It is followed by the evaluation of the prototype with autistic children, and finally a discussion on the findings from the evaluations.

5.2.1 Participants selection

For the evaluation purpose, the researcher selected 10 autistic children between 5 and 6 years old from the Zahra's Flowers preschool in Shiraz, Iran. The children were randomly divided into two groups of five. Further, the researcher considered the first

group of students as the experimental group and allowed them use the developed prototype of the proposed model of this study; while the second group of students were considered as the control group. The control group used training in the classroom with PECS-based cards and storytelling books for learning health words. Table 5.1 and Table 5.2 below presents the demographic details of the selected students.

Table 5.1: Demographic Data of the Control Group Students in Zahra's Flowers Pre-School

No	Name	Family Name	Age	Gender
1	Sina	Hamidi	6	Male
2	Negin	Nazari	6	Female
3	Mina	Hatami	5	Female
4	Mahsa	Bardan	5	Female
5	Nader	Sohrabi	6	Male

Table 5.2: Demographic Data of the Experimental Group Students in Zahra's Flowers Pre-School

No	Name	Family Name	Age	Gender
1	Sara	Kazemi	5	Female
2	Ali	Parham	6	Male
3	Mohammad	Nasimi	6	Male
4	Reza	Godarzi	5	Male
5	Zahra	Karami	5	Female

5.2.2 Evaluation metrics of mobile-based English vocabulary learning prototype

Studies show that the best way of testing vocabulary learning mobile interventions is the Correct Word Choose (CWC) (Abidoğlu, Ertuğruloğlu, & Büyükeğilmez, 2017; Xiong et al., 2018). Therefore, CWC was chosen as the evaluation metrics for this study.

1. Number of correct responses: the value of this variable was reset to 0 at the start of the test.
2. Total number of responses: the value of this variable was reset to 0 at the start of the test.
3. Response: For every individual question, the value of 1 is assigned to a variable if a child selects a correct response for a question and there is an increment by 1 on the value of the variable number, nevertheless, the value of 0 is assigned to the variable. There is also an increment by 1 on the value of variables for the total number of responses.

Brief description of practice or puzzle page, this screen is used in measuring learning vocabulary performances before (pre-test) and after (post-test) the prototype usage. The screen of both pre-test and post-test are similar. The mobile practice or puzzle page has 3 parts, 1. Breakfast, 2. Lunch, and 3. Dinner.

Each part has 10 stages, where in each stage comprises a multiple choice of pictures for each word. Each child with autism according to the word must select one picture of a multiple-choice, for each correct selection, they gain 1 score, and this will be shown on the mobile' screen, and if they make an incorrect selection, the system gives 0 scores to them. After selecting the picture, the next stage automatically shows, until they complete the 10 stages, At the end, the system shows the assessment page which displays the score and motivation message; according to the correct answers, the assessment pages colour are different, for example if the score was 1 to 5, the assessment page was blue, otherwise,

if score was 6 to 10 the assessment page was green. In the final evaluation, the researcher calculated the scores of each student for 3 stages.

At the end of this experiment, comparisons of results were made on the autistic children's performance of the pre-test and post-test for both groups to see if the proposed model helped the students better than traditional training in a classroom environment.

5.2.3 Examine the effectiveness of mobile-Based English vocabulary learning prototype

The analysis result was utilised in examining the prototype's effectiveness based on the correct responses percentage in the post-test. Further, in the analysis, each participant graph undergoes independent examination, so as to assess occurring variations in performances from pre-test to post-test.

5.2.4 Survey

After testing the prototype of the application performance, a survey-based questionnaire was conducted for the purpose of evaluating the application prototype as regards it's usability as well as effectiveness. The questionnaire was also conducted to gather feedback from the users. The questionnaire is of two sections as thus:

- Effectiveness of the prototype's performance
- Usability – the design of the question was in accordance to the Technology Acceptance Model (TAM) created by (Davis, 1986),

The participants of the survey were the family of autistic children and teachers who teach children with ASD. Details from the survey, alongside the analysis feedback are presented in the later part of this chapter (Section 5.6). All questions in the survey are based on a 5-points Likert scale. A five-level Likert scale was used for the collection of agreement or disagreement level from participants. Ranging on a Likert scale, 1 denotes:

‘strongly agree’; 2 denotes ‘disagree’; 3 denotes ‘neutral’; 4 denotes ‘agree’; and 5 denotes ‘strongly agree’.

5.3 Evaluation of the proposed application prototype

The proposed application prototype was critically evaluated via dual evaluation methods, of which the first was a test of autistic children (pre-test and post-test), which was conducted to evaluate the performance of the application prototype. Further, a survey was used in gathering feedbacks regarding the effectiveness and usability of the application prototype. The employed methods as well as the produced outcomes all through the evaluation process are presented in the next section.

5.3.1 Evaluation of mobile-based English vocabulary learning application-Test

This section describes the evaluation conducted by providing adequate information on the employed instruments as well as carried out procedures. In conclusion, the result analysis is being presented.

5.3.1.1 Procedure

This research followed the evaluation methods proposed by other researchers and performed it in 4 stages, which are: Introduction to the program and evaluation process, English pre-test, prototype usage, and English post-test.

(a) ***Introduction to the program and evaluation process***

In this stage, the researcher conducted two seminars of 2 hours each for the selected children with autism in this study to make them familiar with the evaluation procedures and the experiment details. This helped the researcher to ignore each time description of everything for every single person involved in the evaluation procedure. The first seminar was conducted in Zahraz's Flowers pre-school for the experimental group, and the second seminar was conducted in Zahraz's Flowers pre-school for the control group in this study.

In these seminars, the participants learned how this experiment works and how to use the mobile-based interventions involved in this experiment. Also, in these seminars, the teacher in the second group learned how this experiment works in the classroom environment and how to use the training-based interventions involved in this experiment.

(b) ***English pre-test***

To have a comparative result of the students before and after using the prototype, the researcher conducted a pre-test of English words for the selected students in the two groups. To do the evaluation of the prototype, the researcher installed the developed prototype in 10 personal Mobiles in Zahra's Flowers pre-school. The English pre-test was a mobile practice-based application (Section 5.2.2). This step was done under the supervision of their teachers at pre-school.

In this test, a group of 30 easy healthy food words was selected to pre-test. Each word worth one mark if they selected the correct word, and the total mark for this pre-test was 30 marks. Their scores assess the accuracy and familiarity with learning the words. Table 5.3 shows the pre-test result of the students.

Table 5.3: Marks for the English Pre-Test

No	Name	Score
1	Sina	24%
2	Negin	17%
3	Mina	17%
4	Mahsa	20%
5	Nader	24%
6	Sara	21%
7	Ali	24%
8	Mohammad	21%
9	Reza	20%
10	Zahra	17%

(c) ***Prototype usage (Experiment)***

This is the main stage for evaluation. To evaluate the prototype, the researcher installed the developed prototype into 5 personal mobiles for the first group, in Zahra's Flowers pre-school. This stage for two groups, was a 3-week long stage which consists of 15 sessions. Each session was for 40 minutes and five sessions per week (the schedule for the English language is five sessions per week for those in pre-school).

The 5 students of the first group, were sitting in the class at the same time to avoid noise and disturbance while using the prototype. The 5 selected students (first group) of Zahra's Flowers pre-school were the experimental group of this study, and the other 5 students (second group) of Zahra's Flowers pre-school were the control group for this experiment. At the same time, the 5 students of the second group, were sitting in the other class and they were learning health-words with a teacher, according to the traditional method with cards and story book. The proposed model's prototype was being used by the 5 students (first group), and the other 5 students (second group) were using traditional training for learning the Health-Word in the classroom.

(d) ***English post-test***

At the end of the fifteen sessions for both groups, a post-test was conducted for the whole group of 10 students. In the post-test also like the pre-test, to do the evaluation of the prototype, the researcher installed the developed prototype in 10 personal Mobiles in Zahra's Flowers pre-school. The English post-test was a mobile practice-based application (Section 5.2.2). This step was done under the supervision of their teachers at pre-school.

In the post-test also like the pre-test, a group of 30 easy healthy food words was selected for the post-test. Each word worth one mark if they selected the correct word, and the total mark for this post-test was 30 marks. Their scores assess the accuracy and

familiarity with learning the words, and the result for the post-test is described in table 5.4 below.

Table 5.4: Marks for the English Post-Test

No	Name	Score
1	Sina	26%
2	Negin	20%
3	Mina	25%
4	Mahsa	25%
5	Nader	26%
6	Sara	90%
7	Ali	90%
8	Mohammad	94%
9	Reza	87%
10	Zahra	94%

5.3.2 Evaluation of mobile-based English vocabulary learning application-Survey

This section describes the evaluation conducted by providing information on the instruments used and procedures carried out. Finally, the analysis of the results is presented.

5.3.2.1 Instrument used

After testing and evaluating the prototype of the Mobile-Based English vocabulary learning application performance, a survey was conducted for the purpose of evaluating the application prototype as regards its usability as well as effectiveness. The questionnaire was also conducted to gather feedback from the users. The questionnaire is of two sections as thus:

- Effectiveness of the prototype's performance
- Usability – the design of the question was in accordance to the Technology Acceptance Model (TAM) created by (Davis, 1986),

The participants of the survey were the family of autistic children and teachers who teach children with ASD. Details from the survey, alongside the analysis feedback are presented in the later part of this chapter (Section 5.6). All questions in the survey are based on a 5-points Likert scale. A five-level Likert scale was used for the collection of agreement or disagreement level from participants. Ranging on a Likert scale, 1 denotes: 'strongly agree'; 2 denotes 'disagree'; 3 denotes 'neutral'; 4 denotes 'agree'; and 5 denotes 'strongly agree'.

5.4 Tools

The tools used in this stage for evaluation purpose are as follows:

1. A group of 30 words of healthy foods, set of words used in the practice-based application (pre-test and post-test), and word training application. Table 5.5 shows these 30 words for the pre-test, post-test, and word training application.

Table 5.5: 30 Words of Healthy Foods for the English Pre-Test, Post-Test

NO	Breakfast words	NO	Lunch words	NO	Dinner words
1	Boiling egg	11	Chicken	21	Almonds
2	Butter	12	Fish	22	Apple
3	Cheese	13	Juice	23	Banana
4	Chocolate	14	Meat kebabs	24	Fruit salad
5	Fry egg	15	Noodles	25	Olive
6	Honey	16	Pita bread	26	Pizza
7	Jam	17	Rice	27	Sandwich
8	Milk	18	Salad	28	Soup
9	Pancake	19	Shrimp	29	Walnut
10	Toast bread	20	Spaghetti	30	Yogurt

2. A group of 30 healthy food words in the form of cards and storybooks was used for traditional training in the classroom.
3. 10 personal mobile phones have been used to install the prototype and evaluate them.
4. Microsoft Excel software and SPSS were used to draw tables and graphs of the data collected. Graphs were used to show pre-test, post-test, and survey results to better understand the results and easier analysis to draw conclusions about the performance of participants, and effectiveness & usability of the prototype.

5.5 Results

5.5.1 Overall performance (pre-test and post-test)

Dual test was conducted to evaluate the prototype in term of performance of the children with autistics. The test consists of two stages (pre-test and post-test) as described in Section 5.3. During the pre-test and post-test, a collection of 30 words were presented in a mobile practice-based application to the students of both groups. Figure 5.1 – Figure 5.4 shows the percentage performance for all participants, as regards the number of correct responses during the pre-test, and post-test, via line charts and clustered column charts. Line charts for pre-test and post-test show two lines, thus indicating the result of both groups.

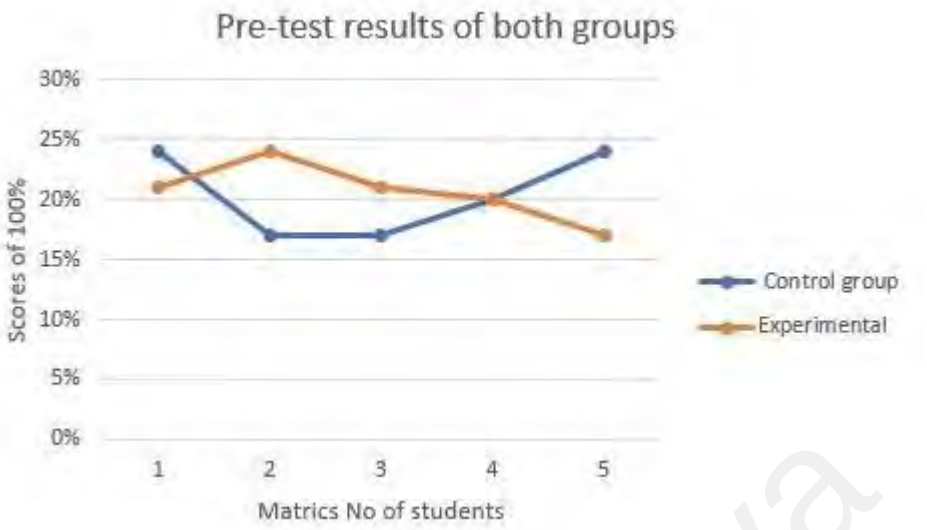

Figure 5.1: Line Chart Result for the Pre-Test of Both Groups

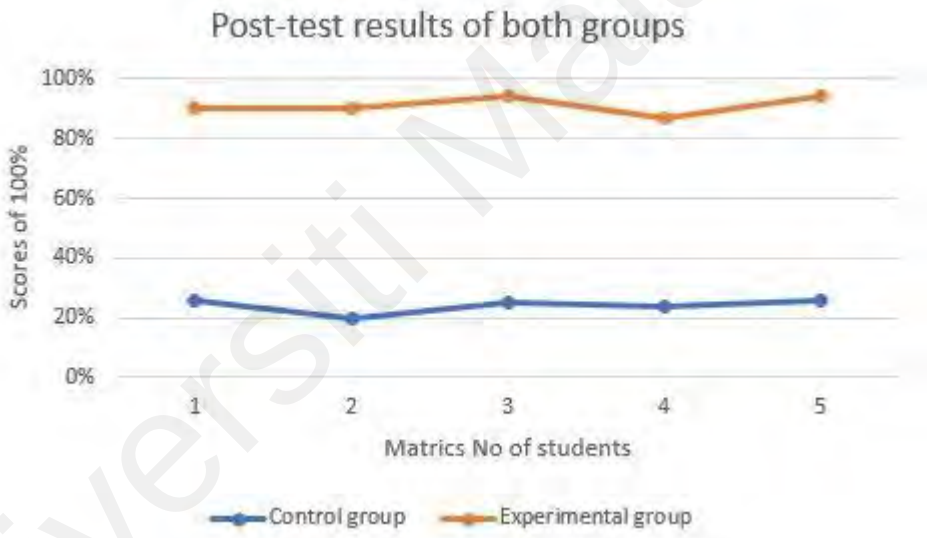

Figure 5.2: Line Chart Result for the Post-Test of Both Groups

Clustered column charts shows two columns as well as a line running through them, where each column, in a sequence (from the first column (pre-test result) i.e., the leftmost column to the second column (post-test result) i.e., the rightmost column), corresponds to an individual participant i.e., from the first participant to the fifth participant in each group (control group and experimental group). The Figure 5.3 and Figure 5.4 depicts the percentage performance of each children with autism in terms of the number of correct responses during pre-test, and post-test in the separate groups of the control group and

the experimental group through clustered column charts. The line shows the average number of correct responses for all the participants in the post-test.

Among the children in the control group, as an average, the participants could recognize 7 words accurately, resulting to 24% of the whole 30 words. As a result, the children in the experimental group could recognize an average of 27 words more than the control group, which shows a difference of 91%. This shows that the experimental group performed better than the control group in learning healthy food words accurately. The result of the post-test among the students of both groups shows that there was a significant difference (67%) between the results of the experimental group and the control group, and it shows that the prototype affected the performance of the children with autism in learning English healthy food words.

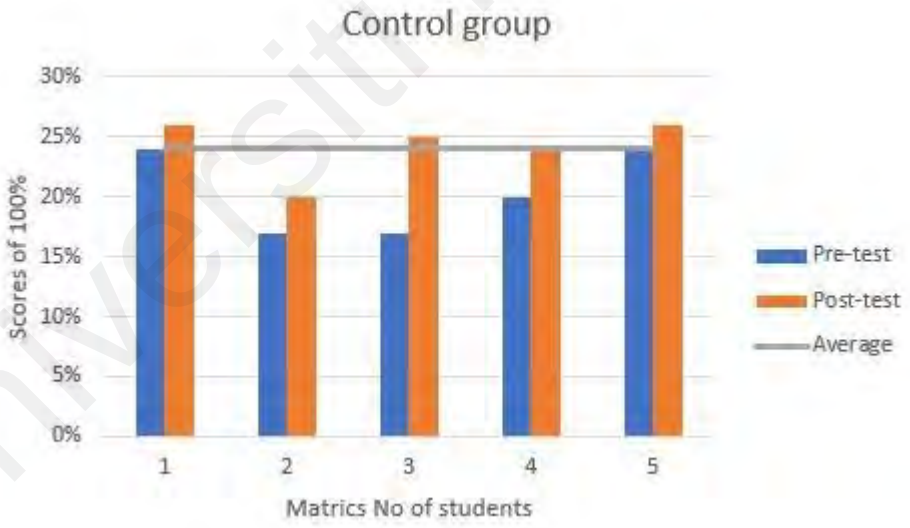

Figure 5.3: Clustered Chart Result for Pre-Test & Post-Test of Control Group

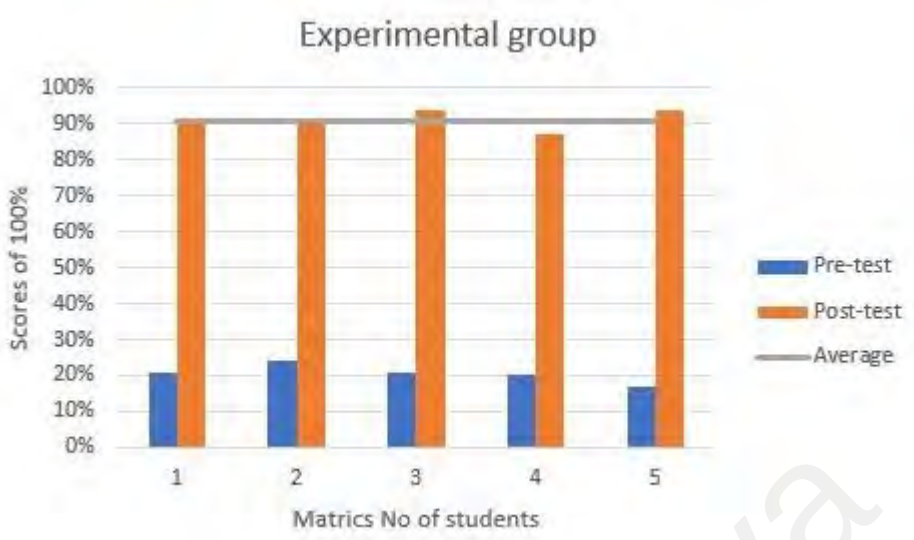

Figure 5.4: Clustered Chart Result for Pre-Test & Post-Test of Experimental Group

5.5.2 Survey

After testing and evaluating the prototype in terms of performance, a survey was conducted for the purpose of evaluating the prototype as regards it's usability as well effectiveness. The survey questionnaire comprised two parts, as already described in Section 5.4.2. Eight responses were gathered from parents and teachers of children with autism. A 5-points Likert scale was employed for the gathering of data on the disagreement and agreement level of the participants. Ranging on the Likert scale, 1 denotes: 'strongly agree'; 2 denotes 'disagree'; 3 denotes 'neutral'; 4 denotes 'agree'; and 5 denotes 'strongly agree'.

The first part of the survey comprises the evaluation of the prototype's performance as regards its effectiveness, in ensuring that the learning vocabulary of autism-inclined children are improved. Figure 5.5 illustrates feedback gotten from the respondents.

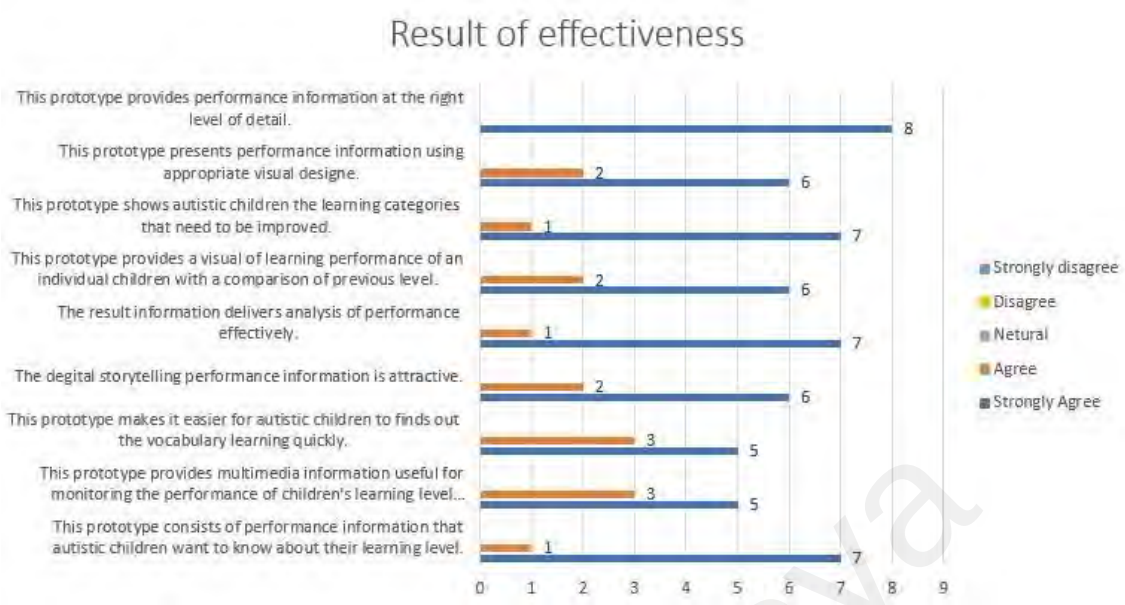

Figure 5.5: Result of the Fulfilment of Effectiveness

Table 5.6 highlights the overall responses retrieved from the participants for the first phase of the survey. The last three rows of the table presents the calculated standard deviation, median and mean to rate the scores of overall responses in evaluating the effectiveness of the performance of the prototype, to improve learning vocabulary performance among autism-inclined children. In Table 5.6, EP denotes Effectiveness Point (refer to questions in Appendix A). The mean scores above 4, which demonstrates that the prototype performance has been effective in improving vocabulary learning in children with autism.

Table 5.6: All Responses to Evaluate the Effectiveness of the Prototype and their Mean, Median and Standard Deviation

Respondent	E-1	E-2	E-3	E-4	E-5	E-6	E-7	E-8	E-9
1	5	4	4	4	5	4	4	5	5
2	5	5	4	4	5	5	5	5	5
3	5	4	5	5	5	5	5	5	5
4	5	5	5	5	5	5	5	5	5
5	5	5	5	5	5	5	5	5	5
6	4	5	5	5	4	4	5	5	5

7	5	4	4	5	5	5	5	4	5
8	5	5	5	5	5	5	5	4	5
Mean	4.87	4.62	4.62	4.75	4.87	4.75	4.87	4.75	5
Median	5	5	5	5	5	5	5	5	5
Standard deviation	0.353	0.517	0.517	0.462	0.353	0.462	0.353	0.462	0

The second section contains questions for evaluating the prototype's usability. The questions were adopted from Technology Acceptance Model (TAM) proposed by Davis (1989). Figure 5.6 presents responses by the participants as regards the use of the prototype performance.

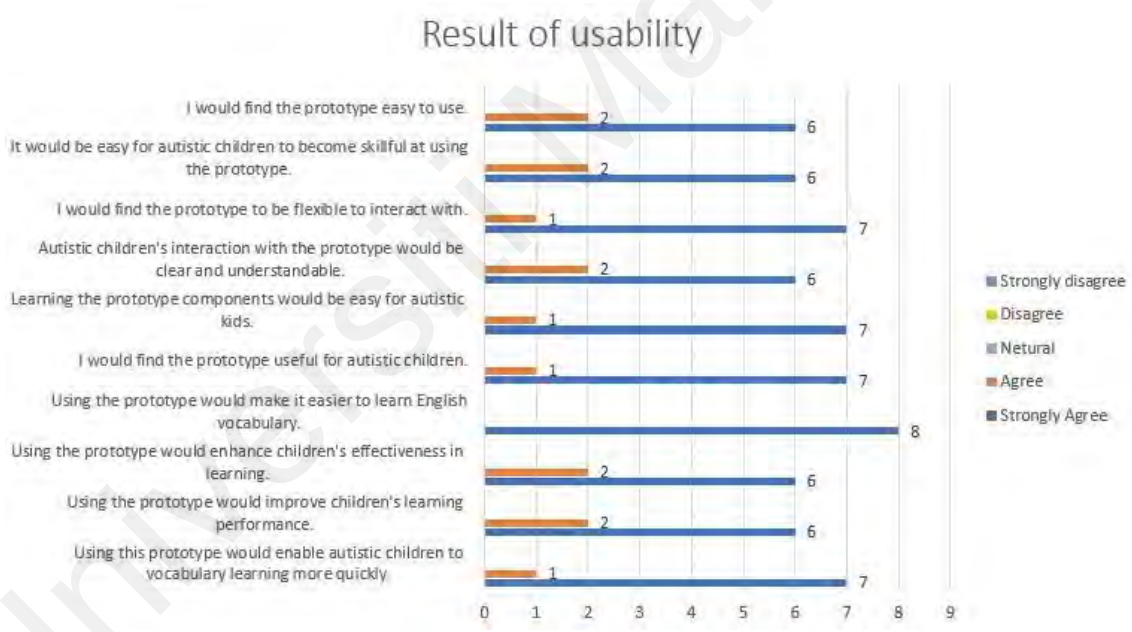

Figure 5.6: Result of the Fulfilment of Usability

Table 5.7 presents the entire participants response for the second part of the survey. The last three table rows presents the mean, median, and standard deviation, as calculated in rating the responses scores, as regards showing their experiences based on the use of performance by the prototype In Table 5.7, UP represents Usability Point (refer to questions in Appendix A). The mean scores of usability are more than 4, thus indicating that the prototype design met the aspects of usability.

Table 5.7: All Responses to Evaluate the Usability of the Prototype and their Mean, Median and Standard Deviation

Respondent	U-1	U-2	U-3	U-4	U-5	U-6	U-7	U-8	U-9	U-10
1	5	4	5	4	5	4	4	5	5	5
2	5	5	4	5	5	5	5	5	5	5
3	5	5	5	5	5	5	5	5	5	4
4	5	5	5	5	5	5	4	5	5	5
5	5	5	5	5	5	5	5	5	4	5
6	5	5	5	5	4	4	5	4	4	5
7	5	4	4	5	5	5	5	5	5	5
8	4	5	5	5	5	5	5	5	5	4
Mean	4.87	4.75	4.75	5	4.87	4.87	4.75	4.87	4.75	4.75
Median	5	5	5	5	5	5	5	5	5	5
Standard deviation	0.353	0.462	0.462	0	0.353	0.353	0.462	0.353	0.462	0.462

5.6 Discussion

In this section, the results presented in the above sections are discussed.

5.6.1 Overall performance of the children with autism in using the prototype

The result of the post-test among the students of both groups reveals that there was a significant difference (67%) between the post-test results of the experimental group and the control group, and it shows that the prototype affected the performance of the children with autism in learning English healthy food words.

5.6.2 Effectiveness and usability of the performance of the prototype

The results from the survey reveals the mean scores to be more than 4, indicating that the performance of the prototype was effective and usable. Strategies like multimedia instruction audio and visual are well designed, thus demonstrating that the prototype performance is effective in improving vocabulary learning among autism-inclined children.

5.6.3 Usability

Also, the most common methods used in this model are well designed and included in the proposed model, which is convenient and usable in the child's interaction with the learning environment. Based on the results, the mean scores of usability are more than 4, thus revealing that the prototype design has achieved the effectiveness and usability aspects. This further indicates that the design and application of the prototype model provided a more effective learning environment for learning the vocabulary of children with autism. The proposed process model provides a mobile-based intervention to support the design of a performance prototype by learning new words, improving English vocabulary, and development of language learning skills using interactive mobile technologies.

5.7 Summary

This chapter conducted the evaluation of the prototype based on pre-test and post-test among autism-inclined children, who were participants of the experiment. The results has been presented as well. Form the evaluation results, it was discovered that there was improvement in the children's performance after they used the prototype. Further, this chapter conducted an evaluation on the effectiveness as well as the usability of proposed process model for the prototype performance. The evaluation results indicates that the performance of the prototype was effective and usable, and the prototype performance in improving vocabulary learning among autism-inclined children.

The next chapter will present the conclusion and future work of this study.

CHAPTER 6: CONCLUSION

6.1 Introduction

This chapter concludes the research by highlighting the achievement of the research objectives, presents the research contribution, limitations, and future work.

The research commenced via a critical literature review on autistic children and their basic behaviours. This was followed reviewing the literature on the vocabulary and strategies used in providing vocabulary instruction as well as the interventions of educational methods for teaching the children and use of MBI (Mobile-Based Interventions) for autistic children was conducted as well based on the existing studies. During the literature review, strategies used, potential benefits of using MBI to teach vocabulary and reading comprehension, alongside vocabulary building model/framework were three main aspects identified. Hinged on the three main aspects alongside autism behaviours, a new process model, MB-VBM was proposed. MB-VBM comprises four main phases, which defined the proposed model's features, they included: learning phase, practice phase, and design UI.

To evaluate the proposed model prototype, 10 autistic children between 5 and 6 years old, were selected from the Zahra's Flowers preschool in Shiraz, Iran, for experimental purpose. They underwent an experiment where the researcher evaluated their performance as participants with pre-test and post-test in two groups. Further, a survey was conducted after the application prototype has been tested, for purpose of gathering feedbacks in relation to the application's usability and effectiveness. Results from the evaluation conducted, revealed great improvements on the children's performance, after they used the prototype. Also, the survey evaluation results showed that the performance of the prototype was effective and usable and can help in improving vocabulary learning in children with autism.

6.2 Fulfilment of the Research Objectives

At the beginning of the research in chapter 1, the study proposed and discussed 4 research objectives. As the research comes to a close, it is imperative to state that all the objectives have been achieved in a sequential manner.

Objective 1: To identify strategies and methods of vocabulary instruction for autistic children on the current Mobile-Based vocabulary interventions research.

This study conducted a literature review, to identify vocabulary building and strategies that are used in providing vocabulary instruction as well as the interventions of educational methods for teaching autistic-inclined children and the use of MBI (Mobile-Based Interventions) for autistic children. Detailed explanation have been presented in Chapter 2.

The existing strategies and interventions of educational methods for teaching and steps needed for designing a proposed model was achieved. The existing strategies and interventions are presented in Section 2.7. In reference to the existing strategies and interventions, a new proposed model, MB-VBM emerged.

Objective 2: To develop a Mobile-Based model for English vocabulary building using appropriate vocabulary building instructions development for autistic kids.

A new process model is proposed for designing a mobile-based English vocabulary building using appropriate vocabulary building instructions development for autistic kids. This new process model can assist autistic children to learn vocabulary. The components for the framework were identified from detailed literature as described in objective 1. The detailed explanation of the proposed process model is presented in Chapter 4.

Objective 3: To develop a prototype of the model.

The third objective is to develop a prototype of designing the proposed model that was described in objective 2. A design produced from research objective 2, was transformed into a mobile-based English vocabulary building prototype. The detailed explanation of the development a prototype of the model has been presented in Chapter 4.

Objective 4: To evaluate the effectiveness and performance of the developed prototype.

The last objective of this research is to conduct an experimental evaluation of the prototype and analyse the performance of learning vocabulary among autistic children before and after using the prototype (pre-test and post-test). Results from the experimental evaluation indicates that there was an improvement in the vocabulary learning performance of the children after making use of the prototype. Further, a survey was conducted after testing the prototype of the application for gathering feedbacks as regards the application's usability and effectiveness. Results from the evaluation reveals that the prototype's performance was usable and effective, thus its performance also proves that it could be of great effect in improving vocabulary learning among children with autism. Detailed explanations of this is presented in chapter 5.

6.3 Research Contribution

In this study, a new process model, MB-VBM was proposed for designing vocabulary learning using interactive mobile technologies and PECS & DS strategies. The main contributions of this research are as follows:

- This research contributes in improving the design of a vocabulary learning prototype using two combined strategies, which are PECS and DS, by

considering the purpose, components, as well as MBI use in supporting the learning of children.

- A prototype of Mobile-based English vocabulary learning has been developed to show a logical view of the designing model. The prototype of Mobile-based English vocabulary learning proffers opportunity to autism-inclined children to learn 30 healthy food vocabulary items via effectual learning as well as material practicing. Results from evaluation of the experiment reveals that the prototype affected the performance of children with autism in learning English healthy food words.
- The proposed model in this research can be used to design interactive MBI's for these children, and it also helps software engineers to expand this project to address other learning deficits in autistic children.

6.4 Limitation

In all researches, there must be an encounter of diverse shortcomings, especially for projects such as this, at the development phase. Thus, this research is not an exception with regards to facing limitations. Therefore, the limitations are stated thus:

- As discussed in the literature review, there are four categories of behaviours (Language comprehension, Verbal communication, Non-verbal communication, General behaviours). This research only conducted the design of a mobile-based vocabulary builder to develop the language comprehension of autistic children. Additionally, the proposed prototype was evaluated using the pre-test and post-test data from pre-school children with ASD, who were aged 5 to 6 years.
- The focus of the design was on just one behaviour (Language comprehension) and three categories of vocabulary (e.g., 30 healthy foods), which was used as

an instructional content. Thus, the use of the prototype can be only by children with autism that is those who need support with regards to language comprehension improvement and vocabulary learning.

6.5 Future Work

As regards the future work for this research, further improvements can be made on the MB-VBM. Other future directions are stated thus:

1) Digital storytelling can be improved by adding some virtual reality-based environment, wherein real world scenarios are being exposed to the autistic children. An example is, if they are to learn about diverse food items, they could be shown a scenario of a particular grocery store that has several food items placed in different walkways of shelves and asked to visit all those walkways in the store, and explore the placed items in the shelves.
2) Adding diverse groups of vocabulary items or those not yet covered in the proposed prototype can be a great idea for future work.
3) For further evaluation of MB-VBM's usability and suitability, there is a need to conduct component details, which could potentially be enriched further, in such a way whereby the proposed model can be evaluated and used for diverse other skills from different domains (e.g., sentence construction) related to these children.
4) More studies on autistic children in schools who are ages more than 6 years old.

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