A STEM GAME BASED LEARNING APPS MODEL TO ENHANCE CREATIVITY AMONG PRESCHOOLERS

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A STEM GAME BASED LEARNING APPS MODEL TO ENHANCE CREATIVITY AMONG PRESCHOOLERS

ABSTRACT

Although recent digital game-based learning studies have shown the possibility of creating new forms of learning and teaching, it is not clear how Digital Game-Based Learning (DGBL) applications can affect creativity and learning on young children. Hence, the main purpose of this thesis is to investigate whether DGBL technology (tablet and smartphone) can improve creativity and learning skills among children aged between 3 and 6. Thus, this thesis has reviewed the literature based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) principles. The results of the literature review showed that DGBL potentially affects students' ability to develop creative skills and critical thinking, knowledge transfer, acquisition of digital skills and experience, and a positive attitude toward learning. Then, the first experiment of this thesis examined which components of creativity based on the "Analyzing Children's Creative Thinking" (ACCT) framework of games can affect the level of learning in preschool children. According to the components found in creativity development from the first experiment, this research presented a single model of Science, Technology, Engineering & Mathematics (STEM)-based learning application to prove to enhance the learning of preschool children in the second experiment. In addition, in this thesis, a simple DGBL application has been designed and implemented to evaluate the model. The results show that the components of creativity can have a significant impact on the level of learning mathematics and in the next step positively affect science and engineering for preschool children. This thesis provides recommendations and suggestions on how to increase creative skills for motivating and improving learning outcomes in digital STEM games-based learning at the preschool level.

Keywords: DGBL apps, educational games, Game-based learning, preschoolers, Creativity and play

MODEL PEMBELAJARAN BERASASKAN PERMAINAN STEM UNTUK MENINGKATKAN KREATIVITI PADA PRESCHOOLER

ABSTRAK

Walaupun kajian pembelajaran berasaskan permainan digital baru-baru ini menunjukkan kemungkinan membuat bentuk pembelajaran dan pengajaran baru, tidak jelas bagaimana aplikasi pembelajaran berasaskan permainan digital (DGBL) dapat mempengaruhi kreativiti dan pembelajaran pada anak-anak kecil. Oleh itu, tujuan utama tesis ini adalah untuk mengkaji sama ada teknologi DGBL (tablet dan telefon pintar) dapat meningkatkan kreativiti dan kemahiran belajar di kalangan kanak-kanak berumur antara 3 hingga 6. Oleh itu, tesis ini telah mengkaji literatur berdasarkan (Item Pelaporan Pilihan untuk Ulasan Sistematik) dan Meta-Analisis) Prinsip PRISMA. Hasil tinjauan literatur menunjukkan bahawa DGBL berpotensi mempengaruhi kemampuan pelajar untuk mengembangkan kemahiran kreatif dan pemikiran kritis, pemindahan pengetahuan, pemerolehan kemahiran dan pengalaman digital, dan sikap positif terhadap pembelajaran. Kemudian, eksperimen pertama tesis ini meneliti komponen kreativiti berdasarkan kerangka permainan "Menganalisis Pemikiran Kreatif Kanak-kanak" (ACCT) yang dapat mempengaruhi tahap pembelajaran pada kanak-kanak prasekolah. Mengikut komponen yang diasaskan dalam pengembangan kreativiti dari eksperimen pertama, penyelidikan ini mengemukakan satu model pembelajaran berasaskan Sains, Teknologi, Kejuruteraan & Matematik (STEM) untuk membuktikan pembelajaran kanak-kanak prasekolah dalam eksperimen kedua. Di samping itu, dalam tesis ini, aplikasi DGBL sederhana telah dirancang dan dilaksanakan untuk menilai model. Hasil kajian menunjukkan bahawa komponen kreativiti dapat memberi kesan yang signifikan terhadap tahap pembelajaran matematik dan pada langkah seterusnya mempengaruhi sains dan kejuruteraan secara positif bagi kanak-kanak prasekolah. Tesis ini memberikan cadangan dan cadangan mengenai bagaimana meningkatkan kemahiran kreatif untuk memotivasi dan

meningkatkan hasil pembelajaran dalam pembelajaran berasaskan permainan STEM digital di peringkat prasekolah.

Keywords: Aplikasi DGBL, permainan pendidikan, pembelajaran berasaskan permainan, kanak-kanak prasekolah, Kreativiti dan bermain

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LIST OF SYMBOLS AND ABBREVIATIONS

GBL	**:**	Game-Based Learning
App	:	Application
STEM	:	Science, Technology, Engineering, Math
CT	:	Creative Thinking
ACCT	:	Analyzing Children's Creative Thinking Framework
DGBL	:	Digital Game-based learning
HCI	:	Human-Computer Interaction
ARCS	:	Attention, Relevance, Confidence, Satisfaction
CBL	:	Creative-Based Learning
PRISMA	:	Preferred Reporting Items for Systematic Reviews and Meta-Analyses

LIST OF APPENDICES

CHAPTER 1: INTRODUCTION OT THE STUDY

1.1 Introduction

Today, we live in an increasingly complex world that requires individuals to come up with creative solutions to problems for communities and schools (Grammenos and Antona, 2018). The ability to conceive and create new and unique solutions to problems is also a distinct human attribute that can be trained (Cook and Bush, 2018). The results obtained from researcher demonstrate the importance of creativity is recognized as a fundamental skill of the 21st century in education (Stockard, Wood et al., 2018). Early childhood educators are constantly challenged to work with children aged between 3 and 6 (preschool level). Creative and game-based digital educational games can help meet some of these challenges. These games allow children to communicate more effectively with their peers, developing their creative skills by providing conditions such as children's ability to generate original ideas and solving problems (Lanna and Oro, 2019). Children's emotions when enjoying art, painting, and music deepen their creative and critical minds and improve their emotional dimension. Ultimately, all of these skills lead to a child's academic progress (Hooshyar, Binti Ahmad et al., 2018).

On the other hand, the most important age for enhancing creativity skills is 3-6 years old (preschool level). Psychological researches divulge that preschoolers (3-6 years old) compared to other age groups have more ability of imagination. Therefore, teachers at the preschool level can nurture creativity skills to become intrinsic in early childhood (Zupan, Cankar et al., 2018). Studies show that when children's creative skills are neglected in early childhood, they suffer from lower self-esteem in their future lives and face difficulties in constructing and developing solutions. Consequently, children without creativity skills may have trouble acquiring and understanding environmental, learning, math, and science skills (Aflatoony, Wakkary et al., 2018).

In addition, there is an increasing awareness about the potential of games for education and training in many disciplines (Shin and Park, 2019). One of the latest trends in mobile phones is the wave of smartphone apps, which include game-based learning and creativity apps for young children (Shin, 2017). However, research still witnesses a lack of methodologies, guidelines, and best practices on how to develop effective game-based learning and creativity apps and how to integrate them into the actual learning and training processes. This process of integration heavily depends on providing and spreading evidence of the effectiveness of game-based learning apps (Beghetto and Karwowski, 2018).

Prior works on the role of educational media in early learning have focused on a wide variety of topics, like early literacy prosocial, skill acquisition, and adoption of healthy behaviors. According to recent studies, limited research has been carried out on the role of technology and its impact on creativity and learning in young children, particularly at the preschool level (Polizzi, 2020).

The model and frameworks presented in this field were examined. In order to understand the role and impact of fostering creativity for children learning in the digital environment, it is necessary to design a conceptual model to intervene with these features on children's behavior. Hence, in this thesis, a conceptual model is presented to investigate and discover the effective factors in improving the connection between the components of creativity and raising the level of children's learning in the DGBL environment. The present thesis highlights which components of creativity are more interactive in early childhood in digital game-based learning (DGBL). Moreover, this study focused on how DGBL through fostering creativity to enhance learning among children at the preschool level. In addition, this thesis points out the reason for making use of a combined method in integrating the components of creativity, play, and learning in DGBL games. Furthermore, this thesis demonstrates why designing a pedagogy scheme as a facilitator is important to provide a comprehensive data analysis. The present

chapter, dealing with the overall context of this research, clarifies the motivation for this thesis and, at the same time, explains the objectives and creates the necessary domains for this scientific knowledge in applications for preschool children.

1.2 Background

This study is important since strengthening children's creative skills improves and develops their ability to solve problems, learn, socialize, regulate emotions, and the like. For this reason, most recent research has focused on the effects of education-based digital games and their impact on children's skills and behavior (Aflatoony, Wakkary et al., 2018, Beghetto and Karwowski, 2018). This thesis also focuses on the growth of creativity while playing in the DGBL digital space and its impact on children's learning. In this research, learning, creative thinking, and play are all mutually investigated during the study. Teachers and parents need to be aware of their children's ability to learn and to be creative. As recent research shows creating and using creativity components in the digital gaming space can foster creativity and knowledge through experimentation for children (Shin and Park, 2019). However, teachers' understanding of the concept of fostering creativity in children is of the utmost importance. Teachers and parents as well as friends of children are suitable for helping them develop creativity and learning. Help from teachers and parents can be effective in the DGBL virtual environment where children need support (Beghetto and Karwowski, 2018).

As living conditions improved, child educators, including Vygotsky (1978) and Piaget and Inhelder (1969) in the eighteenth and nineteenth centuries developed theories to support children's progress in different skills (Piaget, Inhelder et al., 1969; Vygotsky, 1987). In this era, teachers and school principals took child development seriously and offered new ways to develop specific skills in children through supporting different forms of play, so teachers helped children because the activities of teachers and children were intertwined (Cohen and Crabtree, 2008). Children share ideas with teachers and parents as well as peers. This fosters

creativity and learning skills. Teachers and parents play an important role in developing creative ideas in children. Accordingly, this coherent educational program (pedagogy) can enhance children's creativity and learning.

Creativity is one of the basic skills in the 21st century that children need for today's modern life. Creativity is defined as the motivation to find a set of solutions to daily challenges using mental and practical skills (Ravenscroft, 2007; Shih, Shih et al., 2010). The creative mind is a personal talent that can also be trained to develop creative and original products. That is the rationale for using digital-based games to teach skills such as creativity to kids and young students (Ravenscroft, 2007; Shih, Shih et al. 2010).These digital games, due to their wide appeal to children, can improve children's creativity in learning to be encouraged as well. In addition, such games improve children's relationships with their peers to serve as a significant force in strengthening collaboration and creative skills.

Fundamentally, the use of such elements as stimulation of imagination, illustration, and curiosity in the design of DGBL games has an effect on strengthening intellectual skills like creativity, divergent thinking, critical thinking, problem-solving, and building social relationships and collaboration (Hwang, Wu et al., 2012; Yang, 2012). Apart from the attractiveness of other factors such as balance and maintaining a positive attitude when using digital games with satisfaction and encouraging students to find solutions to the problems of certain situations are another set of features of digital games (Diefenthaler, Moorhead et al., 2017).

Thinking and creativity allow students to mentally think of different concepts, developing creative ideas. In the 21st century, STEM education has been introduced in the school curriculum. This contributes to sustainable development and educational goals. Creative thinking is well reflected in STEM. Because the purpose of teaching science, engineering, technology, and mathematics in the STEM curriculum is to establish interdisciplinary

relationships and improve the ability to transfer and integrate knowledge to find real solutions in students (Bureau, 2016). This type of training process can facilitate lifelong learning and even improve distance learning, which is the ultimate goal of education (Bureau, 2016). As noted earlier, the tendency to use STEM curricula has increased in recent years worldwide. A large number of teachers also supported the curriculum of STEM. Based on the reports released from recent research, the STEM curriculum has been more effective than traditional methods of teaching in schools. Even in Asian countries including Korea, teachers find the STEM curriculum necessary to improve 21st-century skills (Shin, 2013). But what has so far caused the STEM curriculum to fail is the lack of coherent education policy and teachers' skills in teaching and improving STEM skills. Hence, according to recent research, there is still a long way to go to provide the STEM curriculum at the best quality level in schools (Beghetto and Karwowski, 2018).

Since the age of 3 to 6 is the most important period to develop creative skills for children, the results of this thesis may provide new strategies for designers, teachers, and psychologists about digital games for developing creative skills. Developing these virtual environments in DGBL will not only help children to develop skills such as collaboration and creativity, but also lead to their academic progress. To develop all these skills will have a positive impact on children's future lives.

1.3 Statement of Problem

To date, there is little agreement on the definition of an educational digital game at the preschool level. Meanwhile, scientists have used different definitions for the phrase 'digital games'. Recent research has rarely explored the dimensions of creativity in digital learning-based games. Therefore, research on the subject of adaptation and the effects of DGBL on children's learning is still ambiguous. According to the recent research regarding game-based

learning apps and fostering creativity among young children (3-6 years old), there are some problems that are discussed below:

• Lack of empirical evidence about DGBL (Digital Game-Based Learning) and CT (Creative Thinking) for preschool level - Although in recent studies, digital game-based learning has the potential to provide new forms of learning in education, it remains unclear how DGBL applications can impact young students' creative skills and learning. The empirical evidence for supporting beneficial claims of DGBL applications and CT (Creative Thinking) has not adequately been realized among young children (Lanna and Oro, 2019). Furthermore, the application of digital game-based learning and creativity has not adequately been realized among young children in learning environments. The researchers, without clear and sufficient evidence, cannot gain a deep understanding of the merits and demerits of DGBL games; consequently, researchers cannot provide an effective solution to improve DGBL apps.

• Lack of proper method for evaluating preschool level - In most recent research for young children, the quantitative method has been used. However, there is little evidence of the qualitative approach to investigate children's behavior (Brooks and Sjöberg, 2020). Qualitative methods, especially "case study" for investigating the behavior of young children are very important (Brooks and Sjöberg, 2020). The reason for the importance of using this method in several recent research in comparison to the quantitative method is to provide a deeper understanding of the interviewees' behavior in different dimensions and the interaction of the phenomenon in question (Brooks and Sjöberg, 2020). Although some recent studies have examined dimensions of DGBL separately in different levels of education, lack of a method to cover and analyze the content dimensions, the effectiveness of creativity, and learning efficiency in digital game-based learning for the preschool level is observed (Beghetto and Karwowski, 2018).

• Lack of a single model or framework with the components of creativity and learning for preschool level - In recent studies, researchers have often used several separate frameworks to evaluate the effectiveness of preschool-level DGBL programs. The use of multiple frameworks reduces the accuracy of data analysis, causing problems. Most researchers have noted the lack of a single framework to assess the impact of DGBL games on children's skills (Marsh, Plowman et al., 2018). Hence, evidence indicates that combining components of creativity and learning in a single model or framework in the digital environment can provide better performance for preschooler level.

• Lack of a pedagogy scheme for preschool level - Recent evidence has shown there is not a suitable pedagogy scheme for preschool level (age 2 to 6 years old) in DGBL. Some researchers believed that pedagogy schemes as a facilitator and helper, especially for preschoolers, may provide a better effect on children's behaviors and skills in digital game-based learning environments (Beghetto and Karwowski, 2018).

1.4 Purpose of the Study

Using creative activities through game-based learning apps is increasing for young children (Chen and Lo, 2019). Fostering creativity through digital game-based learning can link preschool-aged children with real-world experiences to the underlying scientific concepts. This encourages children to explore STEM concepts which are embedded in their everyday life (e.g., finding patterns, building structures, and asking how and why questions). This is while the domains of STEM have been deemed essential to prepare children for the workforce for the future. For example, the U.S. Department of Education has predicted significant increases in the need for STEM-related jobs through 2020 (Clark and Teravainen-Goff, 2020). Prior works on the role of educational media in early learning have focused on a wide variety of topics, like early literacy prosocial skill acquisition, and adoption of healthy behaviors. However, the role of digital game-based learning in order to promote creativity and learning

in early childhood is still hazy. Therefore, a conceptual design model and pedagogy need to be developed in designing the features based on the intervention strategies to match creative thinking and improve their learning in digital game-based learning in preschoolers.

The purpose of the study was to examine strategies used in digital game-based learning at the preschool level to determine how digital game-based learning can the development of preschool children's creative skills and learning.

1.5 Research Questions

The hypothesis and motivation to conduct this research was to formulate 4 research questions. These four questions constitute the review process and the achievement of the objectives of the thesis more clearly, which are briefly mentioned below:

RQ 1: What are the strengths and limitations or gaps of existing models and frameworks of DGBL for fostering creativity approach preschoolers to better learning STEM?

The purpose of designing this question is to review the literature on preschool applications for fostering creativity and learning. Exploring the definition of creativity in learning-related digital games as well as its main aspects has also been explored. In addition, this thesis examines existing models, frameworks, methods, and their limitations, followed by techniques used in existing applications. In fact, this research is to answer this question by in-depth review of existing studies and their similarities and limitations are discussed in Chapters 2 and 3.

RQ 2: How can a model of digital game-based learning be developed to enhance creativity among preschoolers to better learning STEM?

The design of this question helps this thesis to create and develop a model that helps the content of behaviors, actions, and components of creativity in children and its relationship

with the amount of learning in digital game education programs for preschool. To answer this question, this research examines recent studies and their limitations. This thesis also examines the techniques used in existing applications to support children's behavior in developing creativity and raising their level of learning. In Chapter 4 (Findings from Experiment 1) of this thesis, an attempt has been made to identify the features of fostering creativity and play in some of the existing DGBL apps to create an integrated model of programs at the preschool level.

RQ 3: How can a prototype of a digital game-based learning STEM app for preschoolers' level based on the proposed conceptual model of the DGBL app enhance creativity and achieve better academic skills for preschool level?

Designing and answering this question help this thesis to view how the prototype of the play-based STEM program affects the behavior and learning level of preschool children based on the proposed model. To answer this question, the second experiment was designed in Chapter 5. The findings of Chapter 5 show how the proposed prototype could affect the level of creativity and children's learning.

RQ 4: What are the effects of the proposed model of the digital game-based learning app on creativity and learning STEM among young children?

The purpose of designing this question is to investigate the effect of the proposed model on the level of creativity and children's learning in STEM. By evaluating the prototype based on the proposed model in Chapter 5, this thesis gains a deeper understanding of the effect of the proposed model on children's behavior, creativity, and learning at the preschool level.

1.6 Research Objective

Considering the mentioned research questions and the explanations in the previous section, in this thesis, four research objectives are designed. These four objectives, which are

mentioned below, show the process of examining and achieving the research hypothesis more clearly.

RO 1: To investigate and identify features for fostering creative thinking through DGBL apps.

RO 2: To develop a model that integrates content, behavioral, and applying components of creativity, roles, and relationship with learning in DGBL apps for preschool level.

RO 3: To design and implement a prototype of a game-based learning STEM app for preschooler level based on the proposed model of DGBL apps.

RO 4: To evaluate the proposed model of game-based learning and creativity apps.

1.7 Rationale, Relevance of the Thesis

This part explains the importance and key issues of fostering creativity skills of learning in DGBL at the preschool level.

Recent studies have reported an increasing trend in the use of digital technology such as touch tablets and smartphones among children. Similarly, the use of digital games has increased among children. This digital technology is within easy access by most children at school and home in that these devices can be said to have become an essential part of children's daily games (Ofcom, 2017). An estimate of 1028 children aged 3 to 5 by the National Literacy Trust in 2019 shows that most children are able to access tablets and smartphones (approximately by 70%) (Clark and Teravainen-Goff, 2020). Tablets and smartphones are on the rise, so it is natural for parents and teachers to turn their attention to downloading apps that are more focused on educating children. Therefore, according to research done, 72% of the best-selling programs for children in Apple application stores are focused on the educational goals of young children (Shuler, Levine et al., 2012). How these programs are selected by

teachers and parents and what their criteria are for downloading applications need further investigation (Khamparia and Pandey, 2018).

Apart from educating children through digital games in cyberspace on tablets, teachers and parents alike are concerned about the negative impact on children's behavior and addiction to excessive use of games as well as its destructive effects on children's health. Hence, what is most evident in parents' and teachers' surveys of the use of these programs in children is the request of parents to further explore the advantages and disadvantages of these games and their impact on children's development (especially in preschool) (Shabalina, Malliarakis et al., 2016). Therefore, research into the impact of these emerging DGBL technologies on children has become a new challenge for researchers. Few studies have examined the effect of creativity components on children's intellectual and behavioral development (Marsh, Plowman et al., 2018). However, the effect that DGBL can have on children's learning, along with fostering creativity, is still unclear and needs to be investigated.

1.8 Significance of the Thesis

This thesis provides various design strategies that can be used in a preschool digital game-based learning program to help teachers develop and learn children's creative skills at the preschool level. This study may also provide tools and resources for teachers to better understand and support children's perspectives on themselves, their peers, their education, and their world. This study will have a positive impact on creating a learning environment based on digital games through early childhood teachers, designers, and supervisors, which not only promotes academic achievement in children but also fosters the creativity of preschool children. As children develop their creative skills, they can use their ability to explore, solve problems, and use their creative skills in learning. Some researchers also believe that digital play-based learning at the preschool level should be considered in human society because it

has a better effect on developing creative skills and focusing on positive relationships between teachers and parents (Beghetto and Karwowski, 2018).

1.9 The Nature of the Thesis

In this thesis, a qualitative study (case study) was used to gain knowledge about the impact of game-based learning and the development of creative skills and learning of preschool children. The study was conducted in Malaysia. Two Montessori preschool teachers, seven parents, and seven 3-6-year-old young children participated in the study. The data were collected from three sources: (a) semi-structured comprehensive interviews, (b) film recording, and (c) observation of children's creative activities and learning, including photographs of paintings, drawings, collages, construction, children's knowledge in the science of engineering technology, and mathematics. A qualitative case study has been used by participants to interact with their world to gain a deeper perspective on how the DGBL environment can improve creative skills and learning.

The researcher was responsible for gathering data and reviewing them using primary analysis tools. Data collection included interviews and intensive field observations and the use of Hatch's (2002) induction method (Hatch, 2002). The use of this qualitative method allowed this thesis to examine data more closely and have a deeper understanding of participating in children's behavior. Through examining observations and collecting data, this research carefully analyzed the data, described, and discovered repetitive themes and patterns. Then the main themes were identified by categorizing the data obtained from open, central, and selective coding. Chapter 3 describes the data gathering and analysis method in detail.

1.10 Scope of research

This qualitative case study included interviews with 2 teachers, 7 parents, and 7 children aged 3-6 at the preschool level selected from Montessori. The qualitative method (case study)

analysis was applied to provide a better conceptual model and prototype of digital game-based learning apps for fostering preschooler's creativity in order to improve learning STEM using three categories of features: promotion of creativity and play, learning, overall design. This study also investigates the pedagogy scheme as a facilitator to develop a conceptual model of digital game-based learning apps to enhance creativity and learning.

1.11 Assumptions, Limitations, Delimitations

Recent studies have shown that the use of video recording techniques from participants' activities has prominent strengths, indicate that this method is very useful (Marsh, Plowman et al., 2018). On the other hand, the study through film recording can be used to complete other research and qualitative approaches such as interviews and observations of participants. In interviews, only observers and researchers ask specific questions from participants and record their responses, while other aspects of the participants' behavior remain uncertain. However, in video recording, this behavioral dimension of the participants' can be repeatedly analyzed by researchers. In interviews and writing, with limited time schedules and official settings limited to a specific phenomenon, which in fact limits the possibility of examining further dimensions of research to the researcher. In a similar situation, it is possible to record participants' observations that researchers may be in one field for a limited time, which may also prevent the perceived aspects of the participants' behavior. Also, the study of participants' perceptions and feelings about the subject at various times during the written interviews would be confusing (Brandt, Weiss et al., 2007). Without an observer, the video recording method, like other methods, can also be said to be limited by the participants during the interview. For example, the participants chosen by the researchers for collecting data may sometimes remove certain data that is unimportant in view of the participant, while such data may be important for researchers.

As mentioned above, limitations, shortcomings, and certain conditions are not usually under the control of the researcher (Creswell, 2021). These limitations can also affect research results. In this study, what was beyond the researcher's control included time and sample size.

This case study was limited to a private Montessori school in Malaysia. Participants in the study were all female teachers, at least from preschool and kindergarten settings. The inclusion of male teachers may have a different view. The young students involved in the study were limited to seven, as most parents did not allow children to study. Therefore, if more participants were present, they could have provided more perspectives for the researcher. In this study, the number of participants is very small. This small number of participants indicates that the result in a large group of young children may differ from this research. Thus, for future studies, a large number of participants for more accuracy in the result are suggested.

1.12 Summary and Organization of the Remainder of the Thesis

This section explains a summary of the thesis highlighting the main activities and related chapters.

Chapter 2 – This chapter explores the literature on preschool applications for creativity and learning. It also describes the definition of creativity and games associated with learning and its main aspects. This chapter reviews existing models/frameworks and their limitations followed by investigating the techniques used in existing applications to support children's behavior in developing creativity and raising their learning levels and describes the gaps in it. In fact, chapter two discusses the limitations of these studies by examining the depth of existing and similar studies.

Chapter 3 – This chapter describes the method used to examine the behavior of preschool children. This includes a review of existing evaluation methods/approaches and their

limitations and theories. In addition, this section demonstrates the reasons for the appropriateness of this method in collecting data and methods of analysis and analysis of data.

Chapter 4 – This chapter presents the findings of experiment 1 include: Observation of the type of creative activity and apps children use based on (ACCT) framework, observation of the type of creative thinking, children's play, and apps children use based on Hughes' Play Types, Game Difficulty and Observation of Creative teaching and learning app children use based on CBL model and ARCS model (Pedagogy). To approach these sub-objectives, the researcher decided (1) to identify support/ features of fostering creativity and play of some existing DGBL apps, (2) to investigate overall design features and supporting (scaffolding) of use, and (3) to investigate the problems of pedagogy of some existing DGBL apps (included STEM).

Chapter 5 – This chapter presents the findings of experiment 2 for evaluating the proposed model of game-based learning and creativity that include: Observation of Creative Teaching and learning app children use & components of STEM-based on Model (Pedagogy and STEM), Observation of the type of creative thinking and children's play using apps based on Model, Game Difficulty. In addition, this chapter explains the significant findings and summaries of experiment 2 that include: identifying a list of important promotion of play, creativity, and STEM learning by the proposed model and describing the reasons for the Limitations of play and creativity, STEM learning.

Chapter 6 – This chapter summarizes the thesis and its main contributions and addresses its limitations. The chapter also discusses the implications of this thesis for research and recommends potential future work.

To recap, in this chapter, the questions of this thesis are addressed. It also includes the overall structure of the thesis, the compilation of its key components, and the relationship between them. This chapter actually provides a thorough overview of the thesis. The following

chapters expound on the issues raised in this chapter. In this way, the main gaps in research and solutions for future research are discussed.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Although recent studies show a strong trend towards digital games and confirm that DGBL can provide a new form of teaching and learning methods, many aspects of this new technology are still unknown and obscure and needs to be addressed including how much DGBL games can affect children's creativity and whether or not it can have a positive effect on the learning level of preschool children aged 3-6. Therefore, to find the answer to this question, this thesis was reviewed studies in this field in the literature. The findings were analyzed using PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) principles. The process of coding and classifying the desired and defined categories occurred at the time of reviewing the articles. The research methods used were different in the reviewed articles. Then, from the general results, the main themes were extracted and presented in the findings section of this study. This chapter includes a review of existing models/frameworks and their limitations, followed by investigating the techniques used in existing applications to support children's behavior in developing creativity and raising their learning levels and described the gaps in it, especially on preschool level (3-6 years old). This chapter highlights key findings, new insights, and effective suggestions on how to increase creativity skills, motivate and improve learning outcomes in DGBL at the preschool level. The results have shown that the use of DGBL games has a positive effect on fostering creative thinking and learning in children.

2.2 Definition of term

2.2.1 Overview of definition of DGBL and CT at the preschool level

Previous researchers have provided various definitions of digital education-based games (Malone 1981, Prensky 2001, Garris, Ahlers et al. 2002, Prensky 2003). Some scholars have

confirmed the interactive nature of these games and have based their descriptions on how interactive these games are in this definition of digital education games as a set of agreed rules and constraints that lead to a specific goal through a challenge (Garris, Ahlers et al., 2002). Another researcher puts the definition of DGBL in his research as a set of educational games that can provide feedback on to what extent a player can measure his/her progress, only through reward, star rating, or rating or changing the game environment or game character. This enhances user satisfaction in this way, providing the level of engagement and motivation needed to motivate the user (Prensky, 2001). On the other hand, the other scientist's definition of DGBL is a policy template where players can enter variables and take actions, and see the consequences of their actions. The purpose of these educational games is not just to entertain users, although it can be considered as an added value. Therefore, using an entertaining quality educational game is one of the education policies (Wouters and Van Oostendorp, 2013).

Another researcher views DGBL as a virtual game aimed at enhancing knowledge and improving skills. By creating challenges for users to successfully meet and overcome each challenge, these games create a critical success in the game and motivate them to continue playing and learning (Kirriemuir and McFarlane, 2004). These educational-based games together provide the user with a sense of curiosity, challenge, innovation, and fun associated with learning the game. A group of scholars believes that these games can help young children with difficulty in their primary learning and facilitate the learning process through engaging, motivating, and engaging interaction (McFarlane, Sparrowhawk et al., 2002). Therefore, this technology is recommended by researchers to be used to help children in learning and developing their skills (Wilson, Hainey et al., 2013).

One of the essential skills of the 21st century that children need for future modern-day life is creativity (Johnson 2009; Trilling and Fadel, 2009). Torrance defines creativity as the motivation to find a set of solutions to face everyday challenges using both mental and practical

skills (Torrance, 1972; Williams, 1972). The creative mind is a personal talent that can also be trained to lead creative and original products (Hu and Adey, 2002). That's why digital education-based games can teach kids and students skills like creativity. These attractive digital games can improve children's learning by increasing their productivity of creativity (Hwang, Chiu et al., 2015).

Creative thinking (CT) can be described as the process of producing a new, effective, and useful product by an individual or group in a social context (Beghetto and Karwowski, 2018). Over time, researchers' views on the concept and definition of creative thinking have changed. For example, Webster in 1994 described creative thinking in terms of the concept and process of creativity, and in the years that followed, he divided the definition into two areas: the process of personal creativity and the process of creativity in the socio-cultural sphere (Webster, 1994; Webster, 2002; Webster, 2016). Csikszentmihalyi (1996) maintains that creative thinking occurs in the interaction between individual thinking and cultural and social contexts (Csikszentmihalyi, 1996). According to Csikszentmihalyi (1996), the creative process is valuable when it is based on knowledge and facts (Csikszentmihalyi, 1996). The creative process is a new strategy that allows teachers that develop divergent and critical thinking talents and skills in children (Creswell, 2021). In educational games based on education, by using elements such as imagination, using the power of illustration, curiosity, exploration, creating challenges, children's skills are driven towards creative thinking, problem-solving, cooperation, and divergent and critical thinking.

Kampylis (2014) holds that it is creative thinking that supports children in generating ideas in their work. Creative thinking enables children to generate and apply their ideas, to experiment, to make their own hypotheses, to ask questions, to experiment with different options, and to explore and analyze their own ideas and processes. Young students can act as creators of new knowledge and phenomena through the creative process and effectively

collaborate and communicate with their peers in the social environment (Kampylis and Berki, 2014). For example, children can share their new knowledge with their peers in creative activities. The process of creative thinking leads to the production and development of possible solutions to solve the problem of different perspectives. In this case, children have the ability to choose the best solution to solve the problem (Hwang, Wu et al., 2012). Children's culture is recognized as having a direct influence on the development of creative products in this age category (preschool) (Creswell, 2021). Apart from attractiveness, other factors such as interaction and maintaining a positive attitude when using digital games are rewarded with satisfaction, and encouraging students to find solutions to problems under certain circumstances is another set of features of digital games (Shin, 2013).

2.2.2 Overview of definition of STEM- learning at preschool level

In the 21st century, STEM education has been suggested for the purpose of sustainable development of educational goals. The use of creative thinking is well reflected in STEM. The purpose of teaching science, engineering, technology, and math in the STEM curriculum is to establish interdisciplinary relationships and improve the ability to transfer and integrate knowledge to find a real solution for students. This type of learning process can facilitate the lifelong learning process and even improve distance learning, which is the ultimate goal of training (Bureau, 2016). Some researchers believe that STEM should be joined with art as a creative process. Technical knowledge while living in a changing society is not enough. Hence, human thinking is stimulated through a combination of aesthetic sense and sensory experiences, and then it has an effect on the productive identity of the idea (Chen and Lo, 2019). The unique idea is formed as a result of combining these senses in divergent and creative human thinking. For example, in the final report of the Select Committee on the Ministry of Culture, Media and Sport (DCMS) in the UK, it is stated that artistic issues should be

recognized as an important issue in a modern education system and therefore letter A (that stands for Art) was added to the STEM stamp and changed to STEAM (Bureau, 2016).

Through STEM training, students gain the ability to make interdisciplinary connections based on individual knowledge, experience, and creativity. Students gain a deeper understanding of them through links between different sciences. Fostering creativity along with the goals of STEM education among young students results in the generation of new ideas. Acquiring these skills in early childhood will develop children's skills to solve really serious problems in the future. Moreover, learning STEM along with developing creative skills may have a significant impact on the level of divergent and creative thinking in children's early learning (Chen and Lo, 2019). As mentioned earlier, the tendency to use STEM curricula has increased in recent years in the world, and quite a few teachers have supported this curriculum. Recent researches have shown that the STEM curriculum is better than the classical and traditional methods of the school curriculum. Hence, teachers find the STEM curriculum necessary to improve 21st-century skills. But what has caused the STEM curriculum to fail is the lack of coherent education policy and the lack of teachers' skills in teaching and improving STEM skills. Based on recent research, there is still a long way to go to provide the STEM curriculum at the best quality level in schools (Kaufman and Beghetto, 2013).

In recent years STEM education has been increasingly included in the school curriculum and creative thinking skills are one of the methods used in STEM science education. Creative thinking, along with STEM education in early childhood, allows children to think mentally divergently about different concepts in science, technology, engineering, and math, and to create new and unique ideas. On the other hand, this training stimulates critical thinking and paves the way for change and progress in the next generation (Kaufman and Beghetto, 2013). Hence, these days it is necessary to improve the skill of creative thinking, contributing to STEM development, and developing learning. This type of education allows children to

acquire knowledge with the meaning of the real world. Integrating the development of creative thinking skills into knowledge acquisition is also important since it facilitates the achievement of new types of learning through creative thinking.

The purpose of this thesis is to investigate the effect of fostering the components of creativity and learning of children in the DGBL environment in a purposeful model. These findings provide a valuable and useful empirical foundation for DGBL game researchers and designers, teachers, psychologists, and curriculum developers in preschool-based digital learning.

2.3 Review of the Literature

This section of the thesis explores the literature on preschool applications for creativity and learning. It also describes the definition of creativity and games associated with learning and its main aspects. In this part of the thesis, existing models and frameworks are reviewed and their limitations followed by investigating the techniques used in existing applications to support children's behavior in developing creativity and raising their learning levels and describes the gaps in it.

Recent research has rarely explored the dimensions of creativity in digital learning-based games, especially among young children (Behnamnia, Kamsin et al., 2020). Therefore, research on the subject of adaptation and the effects of DGBL apps on children's learning is still ambiguous. As mentioned in the first chapter, some issues were observed in recent studies (see figure 2.1).

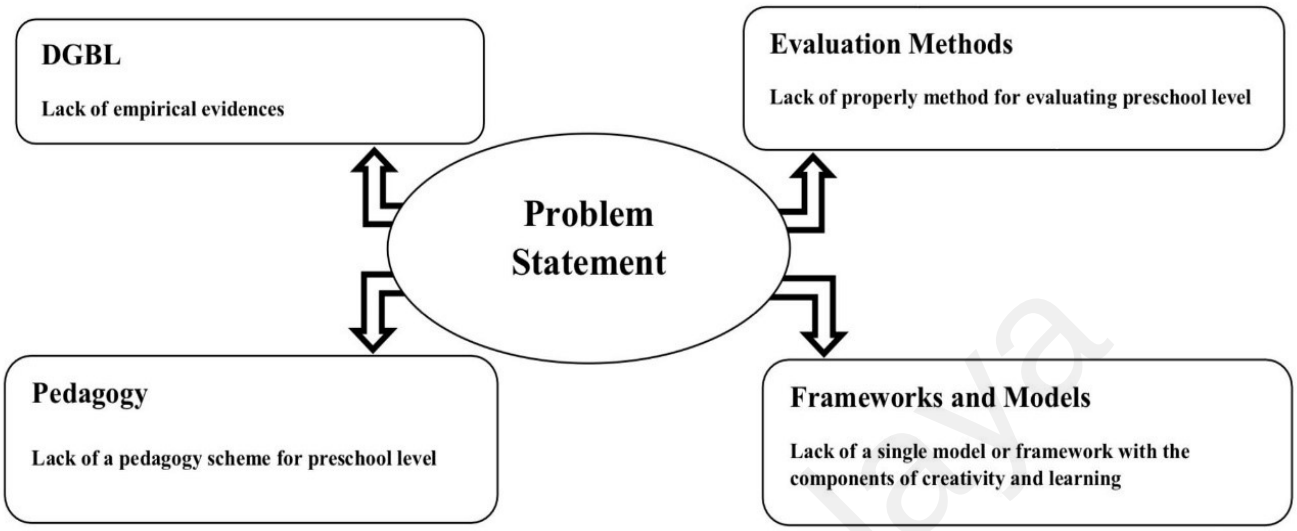

Figure 2.1: Main issues in DGBL & CT at the preschool level

Table 2.1 shows a better and more logical understanding of the process of organizing problem expression. According to the recent research regarding game-based learning apps and fostering creativity among young children (3-6 years old), four issues are highlighted below:

1. Digital Game-Based Learning
2. Frameworks and Models
3. Pedagogy
4. Evaluation Methods

Table 2.1: Problems Statement in DGBL & CT at the preschool level

N	Problem Statement	Explanation	Cover area	Examples of problem	References
1	**Digital Game-Based Learning**	Lack of empirical evidence	1. Technology used in DGBL for young children	• It remains unclear how DGBL applications can impact young students' creative skills and learning.	(Brooks, 2020).
			2. Effectiveness of using DGBL in educational and creativity skills 3. Theories in DGBL and CT	• The empirical evidence for supporting beneficial claims of DGBL applications and CT (Creative Thinking) has not adequately been realized among young children.	(Lanna, 2019).
			4. The demographic variable in DGBL studies	• The application of digital game-based learning and creativity has not adequately been realized among young children in learning environments.	(Karwowski, 2019).
				• The researchers, without clear and sufficient evidence, cannot gain a deep understanding of the merits and demerits of DGBL games; consequently, researchers cannot provide an effective solution to improve DGBL apps.	(Lin, 2020)

Table 2.1: ***(Continued.)*** **Problems Statement in DGBL & CT at the preschool level**

2	**Frameworks**	Lack of a single model or framework with the components of creativity and learning		• In recent studies, researchers have often used several separate frames to evaluate the effectiveness of preschool-level DGBL programs.	(Grammenos, 2018)
				• The use of multiple frameworks reduces the accuracy of data analysis, causing problems.	(Marsh, 2018)
				• Most researchers have noted the lack of a single framework to assess the impact of DGBL games on children's creativity skills	(Marsh, 2018)
				• Evidence indicates that combining components of creativity and learning in a single model or framework in the digital environment can provide better performance for preschoolers level.	(Lin, 2020)
3	**Pedagogy**	Lack of a pedagogy scheme for preschool level	1.Creative learning principles (CBL Model) 2.Creative teaching principles (ARCS Model)	• Recent evidence has shown there is not a suitable pedagogy scheme for preschool level (age 2 to 6 years old) in DGBL.	(Beghetto, 2019)

Table 2.1: ***(Continued.)*** **Problems Statement in DGBL & CT at the preschool level**

		3.Parenting and teacher mediation	• Some researchers believing that pedagogy schemes as a facilitator and helper, especially for preschoolers, may provide a better effect on children's behaviors and skills in digital game-based learning environments.	(Zupan, 2018)
4	**Evaluation Methods**	Lack of properly method for evaluating the preschool level	• lack of a method to cover and analyze the content dimensions, the effectiveness of creativity, and learning efficiency in digital game-based learning for the preschool level is observed.	(Gong, 2020).

Hence, this section is organized to discuss these four items. Also, in this section, in order to highlight and better understand the expression of the problem and the gaps in each field, it is discussed separately in each case.

2.3.1 DGBL and Creative Thinking at the preschool level

DGBL researchers have seen in recent years that there is a tendency among children to use DGBL games via smartphones and tablets at home and at school. Research in this area and its impact on children is still active and dynamic. The study of recent articles shows that the use of digital games based on learning has a growing tendency. Countless articles of this kind have explored new ways of using these games to expand and enhance learning. The potential of education-based games in enhancing other children's skills has also been addressed by researchers (Brooks and Sjöberg, 2020).

In addition, the education-based digital game has the ability to create a more engaging process for young children, unlike traditional teaching methods. Therefore, once young children become involved in the learning process, these digital game-based learning can facilitate and accelerate the learning process owing to the attractiveness and interaction it has (Shuler, Levine et al., 2012). However, designing these games can not only be appealing to children by applying the principles of education and learning. It requires the necessary elements for further communication and increased user appeal in order to satisfy the child's learning satisfaction. Features such as goals, interaction, feedback, and challenges play an important role in attracting and enhancing play feedback among children (Connolly, Boyle et al., 2012). Johnson (2010) stated in his studies that in coming years, education-based games will become the most important factor in enhancing learning in the education system (Johnson, Levine et al., 2010).

In the previous studies, Vogel (2006) has investigated the impact of these educational games on young children compared to traditional methods. This study shows the positive impact and enhancement of children's learning through digital educational games compared to traditional teaching methods (Vogel, Vogel et al., 2006). Several researchers in the field of mathematics, music, and numbers at preschool have also studied this issue and have obtained similar positive results (Divjak and Tomić 2011, Honey and Hilton 2011, Young, Slota et al. 2012).

Some research-based digital games have shown that the use of animations and dynamic images based on storytelling and augmented reality can improve learning effectiveness (Shin and Park, 2019). In another study, the results show that the use of virtual reality has increased the motivation of users and improved their learning. This research examines how a virtual reality system can affect users' motivational talents to track and achieve a goal (Shin, 2017). The findings of another study in 2016 show that the use of technology and smartphones and tablets as an additional screen in the classroom, especially in terms of multimedia learning programs such as digital education and media learning programs for practical students and It

seems to be effective (Shin, An et al., 2016). The results in another study highlight the significant role of using 3D applications in digital applications as a powerful tool in increasing users' cognition and learning (Shin, Biocca et al., 2013).

Clark (2016) in his research showed the results in four dimensions of digital education learning. These four dimensions include "conceptual learning and process learning", "attitude and motivation" and "optimal organization of game-based learning"(Clark, Tanner-Smith et al., 2016).

This study was conducted to demonstrate the potential of digital educational games to enhance learning (Clark, Tanner-Smith et al., 2016). Connolly (2012) and Hainey (2016) examined DGBL at higher levels of education. Aspects considered by these researchers include "types of research methods", "tools and techniques for evaluating and measuring learning outcomes", "describing the characteristics of related games", "making prototypes" (Connolly, Boyle et al., 2012; Hainey, Connolly et al., 2016). These studies indicate that analyzing and evaluating the effectiveness of digital games in the field of education is a growing challenge for researchers and there is a continuing concern about the lack of empirical evidence on the impact of educational games on children. It is worth mentioning that many of these studies tend to examine 20th-century skills such as creative and critical thinking, problem-solving, decision making, or social collaboration. However, it can still be emphasized that these researches are very small and unclear in the field of young children.

Although little research exists on the effects of nurturing creativity and education in young children, all this research confirms that digital games can improve learning by adding creativity and imagination. Betz (1995) stated in his research there is a close relationship between learning and creativity learning; hence, DGBL can be improved by adding visualization, experience, and creativity factors (Betz, 1995). Prensky (2001) has also shown in his research that fostering innovation in digital games helps the student to solve problems (Prensky, 2001).

Brunet (2016) also confirmed children become more educated by using the creativity factors in designing educational digital games. These games helped children to make rapid and creative decisions to solve problems (Brannen, 2017). Hamlen (2009) also found in his research that when children engage in digital games based on creative education, problem-solving becomes easier for them (Hamlen, 2009). Although creativity is an intrinsic talent that only geniuses can use, previous research has shown that creativity can be trained (Torrance 1972; Rose and Lin, 1984; Mayer, 1989; Vass, 2007; Ward, 2007). "Creating by doing" is another way of teaching creativity (Braham, 1992). Braham (1992) pointed out that children through using education-based games have found their ability to provide solutions to problems (Braham, 1992). On the other hand, their thinking is moving towards creative and divergent thoughts (Mayer, 1989).

As mentioned previously, research to investigate creativity and its impact on the learning process in digital games based education for young children, has been limited. Therefore, more evidence is needed to prove the effect of fostering creativity on learning about digital games based on education. In fact, the use of digital games on smartphones and tablets is on the rise among young children. Hence, the parents of these children are worried about the negative impact and addiction to these fascinating games. Some researchers have reported that this game can impair children's motor skills. Therefore, more research is needed to find out the positive or negative impact of these games and children's behavior and performance.

Considering the issues mentioned in the preceding paragraphs, this section of the thesis aims to review existing research in the field of digital educational games and creativity. By reviewing the literature, this thesis identified 67 articles in this field, of which 20 were relevant to the thesis's criteria and goals. As mentioned earlier, this thesis used the PRISMA principles to review and analyze articles on DGBL for young children (Moher, Liberati et al., 2009). Below is the search and review process that was used for the current study including these steps:

1) The process of making plan: Collection from online databases journals, Inclusion and Exclusion criteria of publications, and description of stages of the analysis.

2) Organize and carry out the review: Selection of study, data analysis, data combination, and data coding.

3) Reporting the review analysis of the results and discussion of the findings, to gain an understanding of the current state of the art of studies in enhancing creativity and DGBL applications at the preschool education level and conclusions.

2.3.1.1 Eligibility criteria

In this thesis, systematic analyses of the literature of studies regarding using of DGBL, along with the use of technologies such as tablets and smartphones, to improve creativity in preschool children (ages 3 to 6) have been performed. As shown in table 2.2, searching for data for DGBL applications and fostering creativity was collected from online databases IEEE Xplore, Science Direct, Web of Science, Springer, and Scopus. These sources are well known as the largest database, library research, and documentation. Also, this thesis aims to enhance the quality of studies in the literature review thus the search was confined only to journal articles. Articles chosen in this study were intended to be only in the English language while journals in other languages were removed.

Table 2.2: Inclusion and Exclusion criteria of publication ISI Web of Science

Inclusion Criteria	
IC1	Publication date 2011 (inclusive)- 2020
IC2	Peer-reviewed journals and conference publications in English
IC3	The study is conducted with research articles: qualitative and quantitative report of the game about preschoolers in Digital game-based learning(DGBL)
IC4	The study is conducted with specific aspect of applications that use creativity and thinking skill
IC5	The study uses a learning technology with an integrated creativity
IC6	The study reports at least one or more experimental study on use of fostering creativity in GBL
IC7	The study presents full research result
Exclusion criteria	
EC1	For the conference proceedings, papers published NOT as part of the main conference
EC2	Excluding non-English publications
EC3	Excluding non-Digital game-based learning(DGBL) research
EC4	Excluding reviews, and meta analyses
EC5	Excluding publications with unspecified educational level
EC6	Excluding ineligible publications: Mixed educational level(e.g., elementary with secondary students, or secondary with university student
EC7	Studies that do NOT present research using a pre-post-test design (or control and experimental group)
EC8	Excluding preschool DGBL research unrelated

2.3.1.2 Database and keywords

This study is based on the result of five electronic databases. The initial query search resulted in 67 articles: 16 from Science Direct, 22 from IEEE Xplore, 8 articles from Springer, 8 articles from Web of science, and 13 articles from Scopus. In order to enhance the quality of the studies selected for the literature review, the search is strictly confined to academic journal articles. The number of articles collected in the first phase directly related to the theme of digital game-based learning and fostering creativity for preschoolers has been considered. The most important keyword in the scope of this research is “apps”. Then, the following words were applied in figure 2.2 a total of 67 relevant articles were collected and categorized.

Search terms

1. Educational game
2. Game-based learning(GBL)
3. Digital game-based learning(DGBL)
4. Learning applications

AND

5. Tablet apps
6. Smartphones

AND

7. Preschool level
8. Young children
9. Early childhood

AND

10. Creativity and play
11. Creative thinking

AND

12. Evaluation
13. Impacts
14. Outcomes
15. Engagement
16. Learning
17. Effects
18. Education
19. Motivation
20. Skills

Figure 2.2: Search terms

2.3.1.3 Study selection and data analysis

After glancing over the titles and abstracts, full-text reading, 20 articles in relation to the theme of game-based learning, and creativity in preschoolers were considered (see figure 2.3). Those papers were read thoroughly with the main purpose of finding out a general map for the conducted research on this emerging topic. Selected articles in this review should have;

1. Adopting evidence of advanced digital technology for learning with a game for preschoolers.
2. Having a qualitative and quantitative report of the game about preschoolers.
3. Focusing on a specific aspect of applications that use creativity and thinking skill.

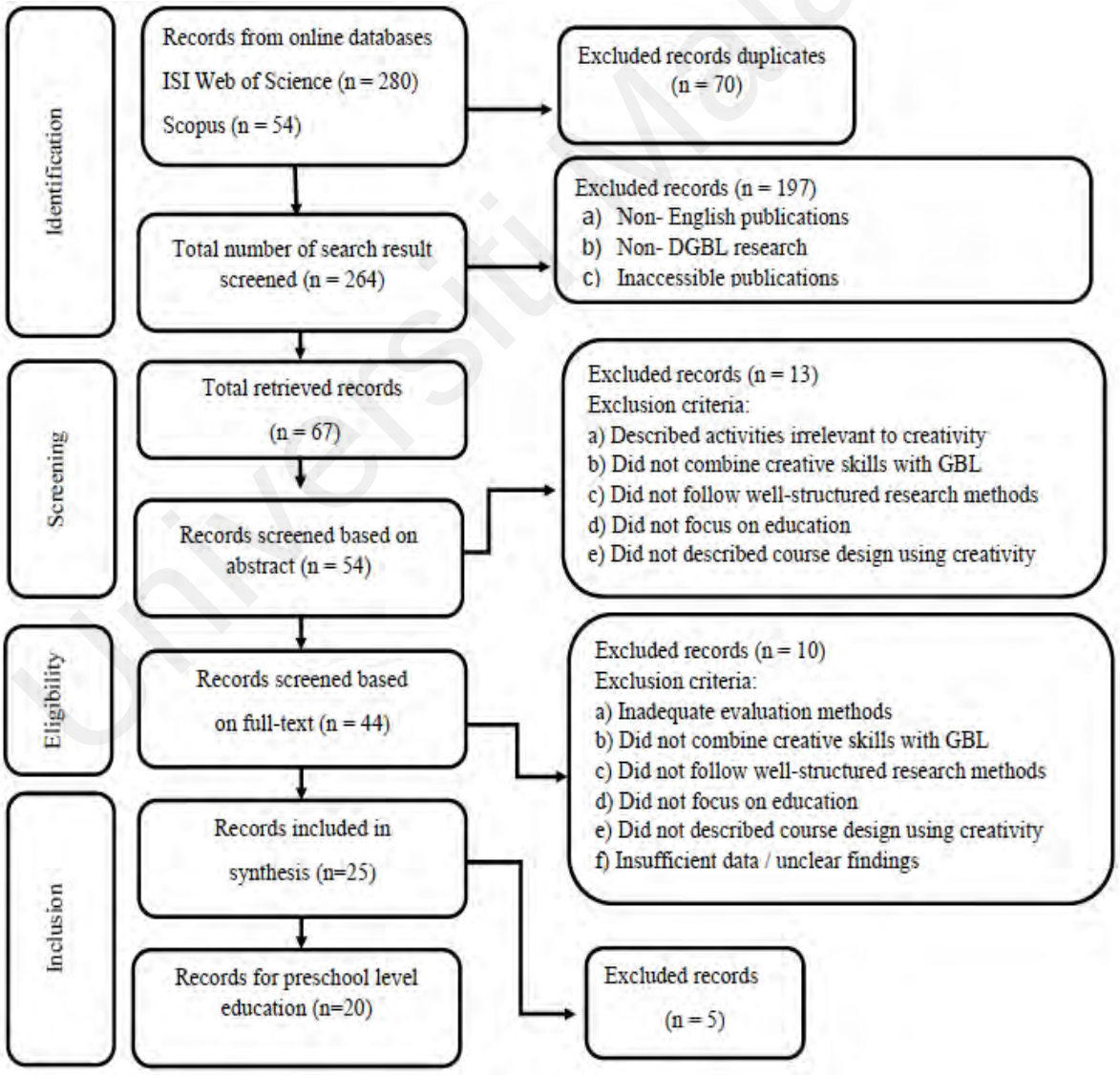

Figure 2.3: Flowchart of paper selection procedure

2.3.2 Result

This classification has been focused in four areas: (1) the objectives of current studies for the application of DGBL approaches/applications for preschoolers in the context of creativity; (2) the impact of using technology (tablets, smartphones) on children's creativity; (3) the theories and pedagogy of recent studies for the application of DGBL applications for preschoolers in the context of creativity; and (4) methods of evaluation to measure creativity while using this type of apps in the current studies. This chapter includes a literature review and the results of research with respect to the category "Effectiveness of using DGBL in educational settings and creativity skills". Since a single study can report more than one sub-category of effectiveness, each study can also fulfill more than one sub-category (see figure 2.4). The majority of preschool level education studies reported that creativity components combined with game-based learning led to "children creative thinking/activity/ skills" and "better learning performance and/or learning gains" in educational settings.

In addition, some of the studies suggest increases in "children motivation and engagement", "children interaction/socialization/collaboration", and articulate improvements in "children's positive perception and attitudes" and "children critical thinking". The findings inform a sound empirical basis useful for researchers and game designers, developers in the field of fostering creativity, and game-based preschool learning (see figure 2.4, table 2.3).

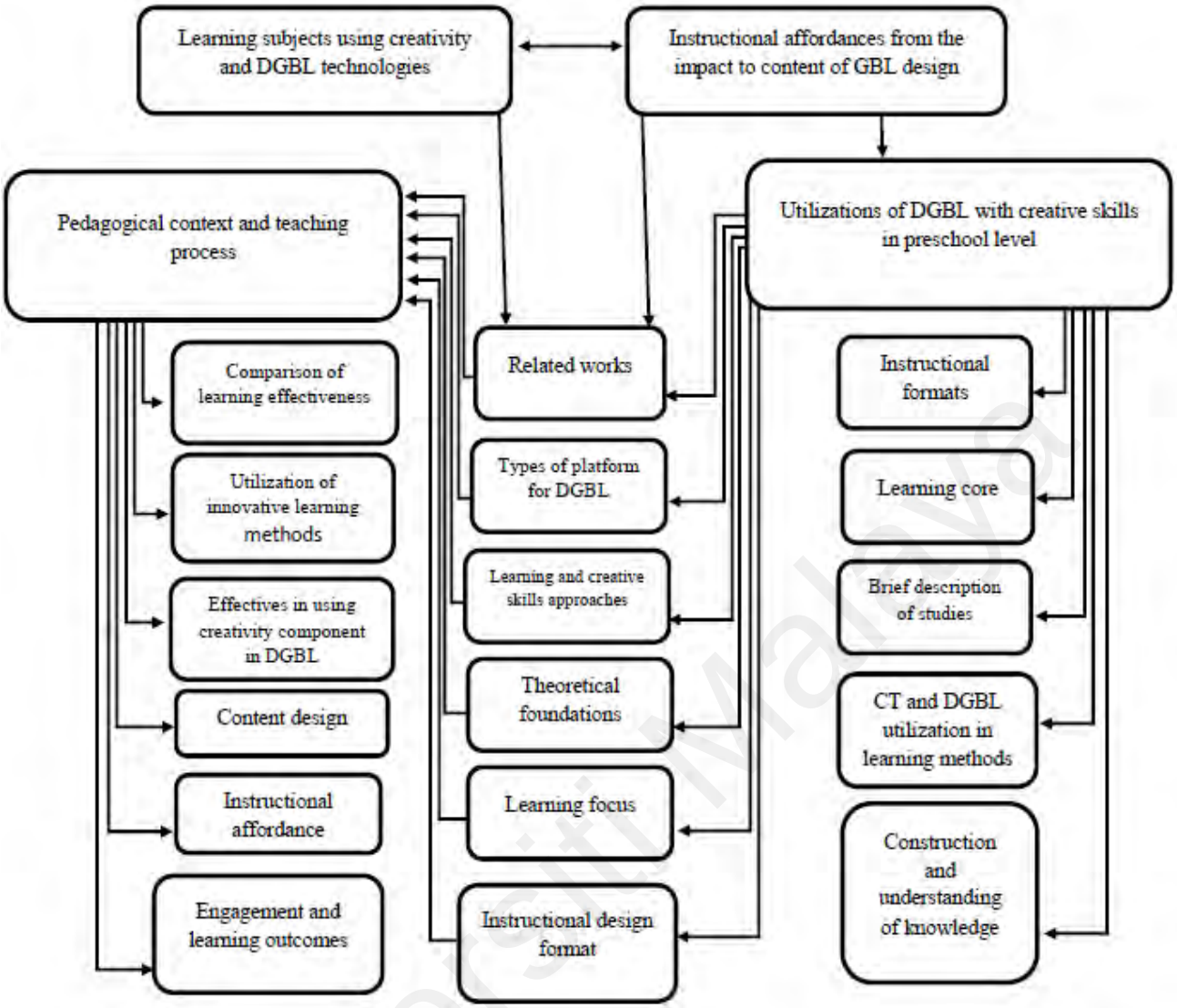

Figure 2.4: Coding scheme of the reviewed papers

*CT: Creative thinking, DGBL: Digital game based- learning

Table 2.3: General overview of related DGBL studies and fostering creativity in preschool level

Research studies	Game-based learning and creativity skills (Objectives)	Study results and observations
Fessakis, G. et al (2013)	To examine the effect of digital games on the creativity of the preschool level under the leadership of an educator to solve special problems.	The results indicated that digital games under the guidance and support of teachers have a positive impact on mental health such as creative thinking on young children and their self-efficacy. Hence, teachers can make children more encouraged to find solutions to their problems.
Kucirkova, N. (2013)	To highlight the value of iPads as a new medium enriching children's experiences with challenging traditional research assumptions.	IPad books are reported to engage children and to have positive effects different from simple digital books.
Brooks, E. et al (2014)	To investigate the impact of digital games on enhancing creativity for learning surroundings in childhood.	The outcome indicated that teachers can be more effective in creating playful structures in the creative skills of children when interacting with children during using digital games with greater intervention.
Lynch, J. et al (2014).	To explore emerging patterns of iPads use among preschool students in Australia (compulsory education).	Encouraging a change in learning policy in Australia through the use of technology and digital games due to tensions between print-based traditions and new digital literacy has led teachers to use technology for young children, and the result of this process shown enhancing learning ability and other children's skills.
Nie, H. et al (2014)	To clarify whether games-based learning can contribute to fostering creativity	The outcome indicated three categories cause fostering creativity among young children; "Learning during digital games", "Learning environmental of digital games" and "Learning both ".
Fessakis, G.et al (2015)	Investigating the effect of using a digital game under the supervision of a teacher in solving problems and creativity in young children.	The results show that the use of digital games has increased children 's skills in creating alternative solutions as well as their self-efficacy in this technology.
Laverick, D. M. (2015)	To explore the use of interactive technologies and media as a development for fostering creativity, art, and learning in childhood.	Digital game-based learning and technology-based teaching can positively affect the creative skills of young children.
Merchant, G. (2015)	To investigate iPad is particularly appealing for young children because of its weight, portability and intuitive touch-screen interface.	The interface, and the story-apps used, may not be quite as intuitive
Kulikovskaya, I. E. et al (2016).	To present and investigate an integrative model of teaching preschool level application (Fairy-tales for modern gifted preschoolers)	The results suggest that the proposed model increased children 's ability to integrate reality and cyberspace and creates a platform for increasing critical and creative thinking skills independently.
Shabalina, O., C. et al (2016)	• Focusing on creative learning approaches and techniques. • Focusing on creative teaching methods and techniques that foster skills and learning outcomes by making students more active and engaged. • Most challenging problem in creative pedagogy is discussed	Combined and used suggested techniques together lead to systemic effects of digital game-based learning and develop creativity and creative thinking of learner
Bae, H. (2016)	To examine the procedure and meaning of creative art curriculum for young children through virtual intercultural exchange.	The results show that teachers found that the curriculum is effective and valuable using digital technology, and decided to expand and enrich the curriculum, which includes programming through digital educational games, as well as art education and creativity.

Table 2.3 *(Continued.)* General overview of related DGBL studies and fostering creativity in preschool level

Suitsu, I. M. et al (2016)	To discuss the game Sandcastle (Castelo de Areia), a virtual story generator in which children can use their preferred characters.	The result shows that this Game can exercising creativity through storytelling among children with age of 4 years old
Arnott. L, et al (2016)	To explore the use of iPads as part of a child-centered data collection approach to understand young children's creativity.	The findings suggest that iPads offer a mechanism to allow children to articulate their creative play and to encourage involvement in the research process.
Mertala, P. (2016)	The present study has given Finnish children a forum to express their ideas and wishes for the use of digital media in preschool.	Taking pictures while playing with digital games on the market has been the most popular activity for young children.
Leggett, N. (2017)	To examine the role of the educator as an intentional teacher within Australian early learning environments and investigates the relationship of this role to children's developing creativity.	The role of the educator is pivotal in assisting children in the early development of creative thinking thus challenging their role as educators.
Kokkalia,G et al (2017)	To investigate the use of serious games in preschool education in the domain of math, cognitive & motor skills, creativity, communication, and special education.	Serious games seem to be incorporated into school program in a variety of ways and good quality of games seem to help children to explore different concepts with a variety of media.
Heydon, R (2016)	To study and produce knowledge on how digital multimedia affect children's life progress on the creative aspects.	The results show that in order to create a transferable understanding, advanced multidisciplinary lifelong learning programs are recommended for their children.
Daniels, K (2017)	To explore how much collaboration and communication during using applications in a classroom environment in childhood.	The results show that when using touch tablets in digital games, due to the multifaceted features of this technology, it increases children's playful activities, which in turn stimulates children's participation and increases children's communication with each other.
Raziūnaitė, P. et al (2018)	To evaluate computer games based on music among young children.	The results of this study show that computer games based on music make children very interested in exploring and creating new music sounds, and this in itself is based on creativity and emotional learning.
Chen, C. W. J. et al (2019)	To examine an application of how children, use previous knowledge to link to new knowledge of their life and music.	The results indicated the increasing positive effect to connect knowledge and creativity.

2.3.2.1 Review of existing technology using in DGBL for young children

Digital technology can be a platform for nurturing children's play and imagination. Therefore, many methods have been proposed to study the impact of this technology on children's games. Digital world game methods can affect the real world or vice versa (Marsh, Plowman et al., 2018). Recent research shows that the most widely used new technologies available to children for DGBL games are smartphones and touch tablets (Lanna and Oro, 2019). Research shows that in most schools equipped with new technology, smartphones, and touchscreen tablets have been used, for instance, for extracurricular use, such as environmental science classes or on field trips that are easier to use (Karwowski, Han et al., 2019).

2.3.2.2 Review of existing effectiveness of using DGBL in education and creativity skills in early childhood

According to some research, in contrast to specific rules in school learning, learning occurs more early in childhood and at preschool levels through play. Learning through playing allows children to develop their understanding of the world around them in a manner suitable to their nature. Experts in early childhood development and psychologists encourage children to play and gain more knowledge to enhance their social development. Based on the results obtained, digital games should be designed to make it easier for young children to learn, especially for children up to 6 years old (Grammenos and Antona, 2018).

In the meantime, previous studies have demonstrated that fun games have the potential to stimulate learning by means of providing to young learners with opportunities to experience self-expression, success, collaboration, discovery, immediate feedback, challenge, clear goals, curiosity, competition, and control (Leggett, 2017).

Researchers mostly confirm that the most popular choice of parents for young children (who more consider education area) in applications in markets is digital game-based learning (Squire, 2013). This type of technology and educational game encourages young children to learn and repeat the content learned at school.

On the other hand, these entertaining games can reduce the time children spend to study subjects (Fisch 2014). Studies have revealed that the development of educational content in this type of game can have a very positive effect on preschoolers' growth and future abilities (Kinnula, Molin-Juustila et al., 2017). The existing studies cover a wide area and address different topics including primary education, experience and ability in social skills, and teaching appropriate behavior (Zupan, Cankar et al., 2018).

Few studies have examined the role that DGBL experiences in fostering creativity skills and play and subsequently in the educational topic and learning in early childhood. Among these studies, the majority of preschool level education studies reported that creativity components combined with game-based learning led to "Student creative thinking/activity/ skills" (35%) and "better learning performance and/or learning gains" (25%) in educational settings. Also, 20 percent of studies suggest increases in "student motivation and engagement", and (10%) "student interaction/socialization/collaboration" and (5%) articulate improvements in "students' positive perception and attitudes" and "children's critical thinking".

Such results show that young students are overly focused on virtual information, with results suggesting that children are overly attracted to virtual space and images of complex DGBL systems and creative components. Hence, the result of studies for the evaluation of learning in DGBL indicated moderate learning. Moreover, assessment courses are very short to assess student performance and learning and require longer evaluation and long-term experience.

2.3.2.3 Review of existing theories in DGBL and CT

Researches show that numerous educational digital games in the market for young children aim to maintain direct engagement with their players by applying “learning theory” (Becker, Cummins et al., 2017). The above is consistent with teaching theories such as cognitive theory, flow theory, and constructivism. Based on these theories implemented on these types of games, motivation, and usage in young children can be increased. Based on these learning theories, these digital games can even increase the learner's social skills and provide opportunities for the development of other skills, including creativity (Gee, 2005; Villalta, Gajardo et al., 2011). For example, Wu (2012) examined 567 published articles and found that educational digital games do not apply "learning theory" in their designs and prevented young children from achieving more positive results (Wu, Chiou et al., 2012).

Another example is Yang (2012), who has confirmed that educational digital games require careful research and design that is based on the theoretical foundations of modern education theory (Yang, 2012). If Game designs and learning are structured meaningfully and supported by the theory of learning principles, outcomes will be more likely to be successful (Vygotsky, 1987). In order to design games that teach children and support them in their learning progress, a profound understanding of the theory of game making, information on education, and learning theories related issues is felt necessary (Boyle, Hainey et al., 2016).

Vygotsky (1978) noted in his research that learning occurs when game and social interaction are “active” and “situated” (Vygotsky, 1987). Role-playing environments are interacted by the individual players, making them interact in a condition that allows them to explore the roles of society inside and outside the game. This, in turn, contributes to the development of social skills and attitudes of the players (Squire, 2013). Twining (2010) has introduced a novel teaching method that involves aspects of ‘training by doing’, ‘learning via role-play’, ‘training by being told’, and finally ‘learning by becoming’. The majority of entertainment games

present an environment for users simulating the real world where players acquire social experience while interacting in this environment. If these games are combined with learning techniques, they can form a highly successful model of game-based learning design (Twining, 2010).

In addition, the flow theory constitutes a major influencing factor in motivating playing and learning. The players spend more time and achieve greater accuracy in order to attain their target by enjoying the challenge and their success in completing a task (Csikszentmihalyi, 1993).

Some of the successful digital game designers create and sustain the game flow and achieve a balance between the challenge level and the proficiency level of the player (Boyle, Hainey et al. 2016). Expert game designers apply inner analytics to gather data for adapting challenges to preserve the game flow and receive proper feedback. This model can be implemented in educational games were learning through playing is evaluate (Boyle, Hainey et al., 2016). According to Li and Tsai (2013), constructivism constitutes the major learning theory engaged by DGBL researchers in science education (Li and Tsai, 2013). This research also discusses incorporating learning theories in educational games in order to enhance and optimize DGBL designs.

The relationship between play and creativity and the rise of learning are issues that are crucial for the intellectual and cognitive development of children. Hence, this thesis by compiling a series of existing research examines the extent to which children are using digital games based on education and technology, the rate of emergence of creativity, and subsequently the growth of learning. Most research has used the “Vygotsky theory”. This theory points to the tight relationship between play and creativity development, which in turn increases learning in children (Vygotsky, 1987). Although there is some research on children's creative use of technology and tablets in digital games such as photographing or painting for

children (Verenikina and Kervin, 2011), the need for further research and evidence in the broader field of using digital games on creativity is necessary. On the other hand, the impact of these games along with nurturing creativity on children's learning is highly significant, too.

2.3.2.4 Review of demographic variable in GBL studies

In recent studies, demographic variables are other ways used to compare the results of research on DGBL and evaluation of creativity such as gender, age, socioeconomic status of students, as well as their status in social classes such as western and eastern society. In addition, social groups may also influence children's desire to choose games based on themes.

A. Gender

Researchers claim that gender plays an important role in game choice and game participation. Recent studies have also found that gender is a variable commonly studied in research. The gender variable is considered as a standard variable in researches for measuring according to the history of demographic variables. For example, Beale (2007) noted in his research that the learning level of children in the experimental group was different in terms of gender (Beale, Kato et al., 2007). By examining the learning outcomes of the collected recent studies in the literature review, it can be noted that a number of researchers have indicated that girls choose simpler themes from digital educational games and boys tend to play challenging and exciting games (Paule-Ruiz, Álvarez-García et al., 2017).

B. Age

Another factor to be examined in this study is the age variable. As mentioned earlier, this study has collected and reviewed articles that have only examined ages between 3 and 6. In some cases, however, participants of articles that are younger than three years were included. But what can be deduced from the results of children's performance in this age group (3-6 years old) demonstrated the age group of 4 years and over has a higher interest rate and enjoy

rejecting game challenges. Whereas children under the age of three due to the lack of development of body motor skills were interested to use simpler games (Paule-Ruiz, Álvarez-García et al., 2017).

C. Socio-economic statuses (SES)

The social and economic status of users may be another factor influencing the research, especially for children in a deprived area who do not usually have access to a computer or tablet, and technology research is needed. However, given this factor, the collected data showed no convincing evidence for this variable.

D. Western society or eastern society

A variety of nationalities, eastern or western societies are also among the other issues considered by many researchers in higher education research. The results obtained from the review of the literature show that most of the studies in western societies have been on children. The results of these studies show that children in western societies tend to play exciting games with more challenges, problem-solving, and using creativity skills during learning (Paule-Ruiz, Álvarez-García et al., 2017).

However, a review of researches from eastern societies suggests that eastern children are choosing more entertaining and friendly games for learning. Hence these studies clarified two points. First, much of the empirical research in Eastern societies have been conducted in controlled classroom settings, reflecting the Asian culture, focusing more on academic achievement in educational games and less using components of creativity. Second, the use of digital games is prohibited in most Asian education centers and schools. One reason is that parents and teachers feared the consequences, such as aggressive behavior and addiction in children.

2.3.3 Frameworks and Models

According to recent researches, several papers have addressed primary age (5–11) students; however, based on the summary of recent studies confirm that there seems to be no specific framework for preschooler's level regarding enhance creativity and learning in the DGBL environment. As in table 2.4 shown, only two elementary level frameworks were seen.

Chong (2012) designed a framework using creativity and plays to enhance children's learning in writing. In this research, it was shown that the presence of creativity and playful factors along with the help of teachers would increase learning (Chong and Lee, 2012). Although this framework was designed for children from the point of view of alphabet writing, other aspects of learning in other scientific fields have been neglected. Another difference between this frame and the proposed model in this thesis is that it was designed in 2012 for elementary level kids, not preschoolers.

Another framework is "The C2 framework", designed by Koulouris (2015) also has some drawbacks (Koulouris and Stavroulia, 2015) (see table 2.4). One drawback is to ignore the effect of creativity on learning output. In other words, although the application of creativity factors can be seen in this framework, the researcher's focus has been solely on nurturing children's creativity, not on learning. On the other hand, this framework is not designed for the preschool level again, and the researcher's focus is on the elementary level.

Table 2.4: Comparison of Frameworks and Models in DGBL & CT

Name of Framework/ Model	Feature of Creative activity	Feature of creative thinking	Feature of play	Enhancing learning	Pedagogy assessment	The overall design features	Level of education	References
Web 2.0 model				✓	✓		Preschool level	(Owston ,2009)
PILE model (physically interactive learning environment)				✓			Elementary level	(Yang, 2010)
Constructionist framework				✓			Elementary level	(Baytak, 2011)
BYOD model (bring your own device)				✓	✓		Elementary level	(Kiger, 2012)
ADDIE model			✓	✓			Primary level	(Diah, 2012)
Creative writing learning framework	✓		✓	✓	✓		Elementary level	(Chong, 2012)
(RBeLEs) framework (resource-based e-learning environments)				✓	✓		Primary level	(So,2012)
Mexican instructive model				✓	✓		Elementary level	(Garcia, 2013)
MILS (Mobile Insect Learning)				✓	✓		Elementary level	(Su, 2013)
C2Learn framework	✓			✓	✓		Elementary level	(Koulouris, 2015)
Concept map-embedded gaming model				✓	✓		Elementary school	(Hwang, 2015)
Technological Pedagogical Content Knowledge (TPACK) framework				✓	✓		Elementary school	(Ciampa, 2017)
MBTI model				✓	✓		Primary level	(Khamparia, 2018)
Micro world-based learning				✓	✓		Elementary school	(Wang, 2018)
Proposed Model	**Feature of Creative activity**	**Feature of creative thinking**	**Feature of play**	**Enhancing learning**	**Pedagogy assessment**	**The overall design features**	**Preschool level**	**2021**

2.3.4 Pedagogy Models in CT and DGBL apps

Another important issue that needs addressing is the issue of adhering to an appropriate model of education for learning-based games in the defined age group of preschool children (between 3 to 6 years). There are very few articles on this subject in this particular age group. The result of recent research in this area is not clear, indicating a lack of an integrated scheme of pedagogy for the preschool level. The results of most research suggest a lack of an integrated scheme of pedagogy for preschooler level that enables the researchers to develop and investigate cognitive aspects, creative thinking, and personality development in young students through the presence of teachers and parents.

Education systems are also seeking a model of education that can nurture critical thinking and independent thinking, as well as increase children's ability to relate to their natural environment and find solutions when real-life problems (Cheng and Tsai, 2014). While the day-to-day development of game-based educational applications for children is increasing, these products are structurally deficient in terms of adherence to the principles of education models.

Furthermore, evaluating these applications has also been overlooked in terms of improving intellectual creativity and subsequently enhancing learning (Grammenos and Antona, 2018). Consequently, it is imperative to provide a purposeful model to comprehensively examine the impact of creativity components on the learning rate of preschool children in the DGBL environment along with the help and support of teachers and parents.

Below are two models in which the principles of teaching and learning in the creativity used in this thesis are presented. Models on the principles of **creative learning (CBL Model)** and the principles of **creative teaching (ARCS)** used by most researchers in their evaluation have been explained in detail.

2.3.4.1 Creative learning principles (CBL Model)

Creativity in learning during the last part of the 20th and early 21st centuries has been recognized as a form of formal education and has received increasing attention from scholars. Several authors have argued that creativity should be incorporated into the learning process even as an educational goal (Cheng and Tsai, 2014).

Digital games that have environments that stimulate creativity are considered as good games by players of these games (Verenikina and Kervin, 2011). A player must be creative to succeed in the games (Hamlen, 2009). Games need players to be able to make decisions and give them the opportunity to influence the story of the game. Even in some games, the player can act effectively in changing and designing the game environment and character. Games usually offer many options, which can affect even the game process (Henriksen, 2014). When using digital educational games, it is essential to support creative thinking and use it to acquire knowledge and master new skills. Digital learning, techniques can be a unique challenge to improve creative learning and inspire creativity in the individual (Diefenthaler, Moorhead et al., 2017). Educational games provide an environment for active, collaborative, and creative learning. It allows students and children to discover methods, concepts, and skills quickly and confidently in an environment designed with specific learning components (Karwowski, Han et al., 2019).

There are various types of design principles for educational games in literature; however, only a few researches focus on the creative aspects of learning. Most game researchers and designers have found that using the principles of creative-based learning is the best way to use educational games for learning development (Bellotti, Berta et al., 2010). These principles based on creative- based learning (CBL) model are bellow explained in this chapter.

Using this model in designing educational games, especially for children, demonstrates the control of learner performance depending on their level of knowledge and individual

characteristics. The learning process of the game is understood as a quantitative process in the virtual world. An example includes the time in a digital game where the child has to help the game character to acquire new skills to survive. The child has to adapt to the digital environment around him. Moreover, the child sometimes has to change some play factors. During the game, the child must learn new skills and new techniques. Therefore, the child uses and inspires this digital space and the strategy of helping the main character of the game in the DGBL space to keep the game character alive.

Hence, this skill is recorded in the child's mind as a solution to the problem. In this way, the child uses his creative skills to use other solutions to rescue the game character. At the same time, the child subconsciously acquires new knowledge in the play environment. Thus, this model allows the researcher to select game-related actions depending on his or her current situation and to achieve the learning objectives during play.

2.3.4.2 Creative teaching principles (ARCS Model)

The use of the ARCS model in game-based learning is based on a combination of motivational concepts that are classified into four main categories: Attention (A), Relevance (R), Confidence (C), and Satisfaction (S). These categories represent a set of conditions that support students' learning motivation (Keller, 2000) (see Figure 2.5).

Figure 2.5: ARCS model (Keller, 2000)

Research studies show that the ARCS model can increase participants' intrinsic motivation for learning digital games (see Figure 2.6). The importance of these four categories of motivation is summarized in table 2.8 (see table 2.8).

Figure 2.6: Relationship of Creative teaching principles (ARCS) motivation model (Keller, 2000)

In this thesis, theoretical approaches and practical solutions were considered for one of the most popular trends in modern creativity-based education. The case studies presented in this research describe two of creativity-based education: creative teaching and creative learning. Using these components can be considered a creativity-based educational approach that can foster creativity and creative thinking in young children.

2.3.4.3 Pedagogy in STEM based learning apps

In recent years, the use of digital games for STEM education has been identified as one of the global education approaches needed by 21st-century learners (Kennedy and Odell, 2014). Advances in DGBL game technology mean that the number of digital games in the field of STEM is also constantly increasing and developers are competing with each other (Beumann and Wegner, 2018). One of the goals of STEM creation training is to create a more interactive, more interesting process for understanding the value of STEM issues (Nadelson, Seifert et al., 2012; Basri, Alandejani et al., 2018). It is now more practical to use such games even for kindergarten and preschool education to increase students' interest in STEM (Drummond and Sweeney, 2017; Chien and Chu, 2018; Cairns and Areepattamannil, 2019; Li, Wang et al.,

2020). In fact, the use of STEM concepts in the digital space of digital games allows higher visualization than scientific concepts (Damsa and Jornet, 2016; Deák, Kumar et al., 2021). According to the STEM curriculum, its concepts include several facts and concepts that students need to understand and practice in their daily lives.

Learning the concepts of STEM using regular and traditional instruction may not be easy in some cases (Chien and Chu, 2018). Teachers need support materials to help visualize each concept in order for students to learn, for whom digital games can be one of the best options. Digital games allow students to easily access visual information for each concept in a virtual space. On the other hand, these games cause learners in a virtual space to communicate with the challenges of the game based on their knowledge, and as a result, there is a tendency to be aroused by the continuation of the game. Creating charm and continuing the game is also one of the goals of digital gaming for continuous learning.

DGBL makes users feel happy while learning, while at the same time enabling students to have a better understanding of STEM content, experiencing the problems of the virtual world as well as a meaningful game (Basri, Alandejani et al., 2018; Aalto, Tarnanen et al., 2019; Deák, Kumar et al., 2021). Thus, the use of DGBL not only enhances learning and skills development but also enhances the maintenance of a deeper understanding of STEM. This process also helps maintain an interest in STEM learning (Hesser and Schwartz, 2013). STEM training for teachers in teaching children is also challenging. The goal of most DGBL games is to enhance learning at STEM (Nadelson, Seifert et al., 2012).

Competition in the production and development of STEM-based digital games is currently increasing, indicating the cooperation of many experts in the field (Beumann and Wegner, 2018). These collaborations show that STEM-based digital games undergo a process of systematic and appropriate development for learning has provided a good platform for the designer and expert of digital games (Mulqueeny, Kostyuk et al., 2015).

2.3.4.3.1 Pedagogy models on STEM learning

Recently, several models of educational content knowledge of STEM have also been discussed by researchers in terms of innovation in combining the standard idea of technology educational content (Voogt, Fisser et al., 2013). Innovative models pave the way for educators to advance in critical thinking approaches and education. Some of these researchers believe that if educators use the emotional quotient (EQ) in STEM training, the analysis of social-emotional content in training can lead to better results (Holmlund, Lesseig et al. 2018). Teachers can play a key role in STEM learning, as teachers have been shown to be very effective in integrating technology into students' learning (Holmlund, Lesseig et al., 2018).

Transformation in education depends not only on intellectual progress, but also on social progress. Higher education institutions still face the challenge of providing a robust framework for transformational education in STEM (Damsa and Jornet, 2016). STEM educators need to support a long-term progressive approach with timely teaching tools in education (Aalto, Tarnanen et al., 2019). One of these efforts was made in a joint study between Chinese and Russian universities by Liu (2020), Who concluded that "introducing connection methods", which means more integration of students during the training, has better and higher results than other methods (Liu, Chubarkova et al., 2020). On the other hand, paperlessness for a sustainable future is the impetus for creating new educational solutions through the use of iPads in classrooms and labs (Hesser and Schwartz, 2013).

The University of New Hove has introduced a paperless curriculum for students that have had a positive impact on their teaching and student learning (Hesser and Schwartz, 2013). Digital game interaction in the classroom is even more important for young students as Kevin and colleagues (2015) try out three models called “Genie”(Mulqueeny, Kostyuk et al., 2015). He and his colleagues found that evidence-based e-learning and digital games on

middle school students provide better results for classroom engagement(Mulqueeny, Kostyuk et al., 2015).

In another 2020 study, storytelling and characterization in STEM-based digital games were used as an educational approach. In this study, Hu (2021) called "Once upon a Star" a science-based science education program to promote preschool children's understanding of scientific concepts such as astronomy in stories, and scientific and design activities in early learning (Hu, Gordon et al., 2021). This special topic, The Concepts of Astronomy, began with a science education intervention study aimed at cultivating these preschoolers' conceptual understanding of astronomy in Sydney, Australia. Hu (2021) used a socio-cultural approach to examine the understanding of the concept of these children in this study. Experience and analysis and interviews before and after the intervention, according to the documents of the children's portfolio teachers, show the benefits of the science program for 24 children aged 4 to 5 years (Hu, Gordon et al., 2021).

This study demonstrates the potential of using personal storytelling as an effective strategy in pedagogy and education to introduce expected scientific concepts to young children using this pilot project (Hu, Gordon et al., 2021).

In recent studies, many models have been proposed by researchers, some of which support integration and some of which do not. The researcher found that to understand the new modules, their ability to integrate topics and develop classroom interaction in parallel must be analyzed. Table 2.5 shows some models that have been proposed by researchers in recent studies (see table 2.5).

Table 2.5: Models in pedagogical approaches for STEM education.

No.	Models Developed in Pedagogy	Field	Objectives	Year	Ref.
1.	Genie model	Classroom engagement	Incorporating effective E-learning in middle schools	2015	Mulqueeny, K., et al (2015).
2.	Conceptual framework	STEM integration	Introducing a conceptual framework for integrated STEM	2016	Kelley, T. R., & Knowles, J. G. (2016).
3.	K-12 model	STEM integration	STEM integration with equitable focus on all streams	2016	English, L. D. (2016).
4.	Self-assessment model	Classroom engagement	Promoting self-assessment assignments in higher education	2018	Beumann, S., & Wegner, S. A. (2018).
5.	Competency-based training (CBT)	Classroom engagement	Promoting CBT in universities of Ghana for employable student skills	2018	Wongnaa, C. A. et al (2018).
6.	Design-based learning—Makerspace	STEM integration	Study based on motivational factors affecting elementary students	2018	Vongkulluksn, V. W. et al (2018).
7.	Play-based learning model	Classroom engagement	Use of apps to understand the impact of interactive technology	2018	Miller, T. (2018).
8.	Sense Making model (SMM)	STEM integration	To investigate educators conceptualization of STEM	2018	Miller, T. (2018).
9.	Intelligent tutoring systems (ITS)	STEM integration	To understand effectiveness of ITS in STEM	2018	Graesser, A. C., et al . (2018).
10.	SKOPE IT	STEM integration	To investigate the efficiency of portable ITS in STEM	2018	Nye, B. D., Pavlik, P. I., et al (2018).
11.	Learning assistant program	STEM integration	Development of pedagogical knowledge in learning assistants	2018	Top, L. M., Schoonraad, S. A. et al (2018).
12.	Integrated STEM black box	STEM integration	To address ill-defined gaps of integrated STEM	2018	Gardner, M., & Tillotson, J. W. (2019).
13.	Growing tall poppies program (GTP)	Classroom engagement	To promote students to take STEM subjects in higher studies	2019	Scott-Parker, B. (2019).
14.	Learning management system (LMS)	Classroom engagement	To investigate the use of multimodal quizzes in replacing conventional assessments	2019	Gamage, S. H. et al (2019).
15.	Peer supplemental model	STEM integration	To understand innovation in supplemental instructions	2020	Achat-Mendes, C. et al (2020).

The integration of different currents such as mathematics, science, and technology is an inevitable development for students and educators in the 21st century. Therefore, in order to formulate the integration of different study processes, sufficient information is needed (Council, 2014). However, the main basic educational approaches used in recent studies in the development of advanced technology learning in STEM education include "Self-regulated learning", "Inquiry-based learning", and "Computer-Supported collaborative learning'. Often these three types of learning are based on a constructivist relationship that shows that individuals need to learn how to organize their learning in a group of students and how to benefit from discussion about work and research.

1. Self-regulated learning

Researchers have offered different definitions and models of self-regulated learning, but what most researchers agree on is that self-regulated learning is a constructive process by which students learn different stages of the cognitive, metacognitive, and motivational processes during their learning. They regulate administration and behavior (Winters, Greene et al., 2008). Students with good self-regulated learning skills can use effective learning strategies independently and control their learning process (Hadwin, Järvelä et al., 2011). Self-regulated learning skills with components of cognition, metacognition, motivation, and learning development for students for a lifetime (Saks and Leijen, 2014). This type of educational approach improves students' skills and progress and enables students to orient their learning by increasing their independence.

2. Inquiry-based learning

The concept of inquiry-based learning is defined as the process of discovering new causal relationships. In this process, students test their hypotheses, and conducting experiments or student observations can explore the relationships between these causes (Pedaste, Mäeots et al., 2012). In this process, it is important that the learner is active and takes responsibility for

discovering new knowledge (De Jong and Van Joolingen, 1998). In this process, the basic principles of learning are self-regulation. A 2015 study conducted a systematic literature review to describe the diversity of stages and cycles (Pedaste, Mäeots et al., 2015). In this study, in which 32 articles were reviewed, these five general stages were observed. According to Pedaste (2015), inquiry-based learning begins with the orientation phase. This step is about identifying the challenge to solve the problem. The second stage is conceptualization. At this stage, students define the problem hypothesis by gathering more knowledge and information. The third step is to design the challenge and then respond to the challenge by gathering information and data. The fourth stage is the conclusion and the last stage, the fifth stage, is the discussion. At this stage, all activities and results of other stages will be announced to students of the same year as other stages of research. The steps are performed systematically so that the learning process has a good effect on the students (Pedaste, Mäeots et al., 2015).

3. Computer-Supported collaborative learning

Computer-Supported collaborative learning (CSCL) is a link to digital competence. Recent research shows that STEM-based learning is more effective than other traditional approaches. This has been revealed in several meta-analyzes (Alfieri, Brooks et al., 2011, Furtak, Seidel et al., 2012). The benefits of research learning have been discussed in recent years. Recent studies, however, also show that technological advances can further enhance the success of research-based learning (De Jong, Sotiriou et al., 2014). These researches have shown that if special tips are available along with this digital learning, it can increase the rate of learning (Lazonder and Harmsen, 2016). In order to use research-based learning in advanced environments and technology, digital competency is required and may structure student guidance.

According to the European Framework for Digital Competence, there are five areas of digital competence (Vuorikari, Punie et al., 2016):

1) **Information and data literacy**: To articulate information needs, to locate and retrieve digital data, information and content. To judge the relevance of the source and its content. To store, manage, and organize digital data, information and content.

2) **Communication and collaboration**: To interact, communicate and collaborate through digital technologies while being aware of cultural and generational diversity. To participate in society through public and private digital services and participatory citizenship. To manage one's digital identity and reputation.

3) Digital content creation: To create and edit digital content To improve and integrate information and content into an existing body of knowledge while understanding how copyright and licenses are to be applied. To know how to give understandable instructions for a computer system.

4) Safety: To protect devices, content, personal data, and privacy in digital environments. To protect physical and psychological health, and to be aware of digital technologies for social well-being and social inclusion. To be aware of the environmental impact of digital technologies and their use.

Therefore, it is necessary to draw up some guidelines for teachers can help students to prepare them for the common STEM learning process set up in digital environments such as learning-based digital games. First, students need systematic teacher support to develop self-regulatory skills in STEM learning. Second, students must also have systematic support for developing their digital skills. These skills can include communication, collaboration, and digital content awareness. Third, teachers must have digital equipment competencies, and a coherent teaching framework, such as a question-based learning framework, must be used to enable self-directed and collaborative learning. Teachers should also strengthen learners' independence in choosing different technological tools according to learning goals and preferences (Lin, Shih et al., 2007).

2.3.4.4 Parenting and teacher mediation

The parenting and teacher mediation topic is related to the way parents provide children with access to technologies and then help them use and think about DGBL apps (Clark and Teravainen-Goff, 2020). Early studies of children's interaction with the television show that there are three types of mediation in general: limited mediation, informative mediation, and intermediary mediation (Nathanson, 1999; Warren, 2003). In another study, some researchers have developed tools for evaluating the mediation of parents or teachers when children using applications (Nikken and Jansz, 2014). The researcher expanded it by classifying types of mediation into four intermediary styles, which could be more reliable and more common as follows:

1**) Active mediation** (for example, helping children with what they used when using the app must do)

2) **Limited mediation** (general restrictions such as a time limit for using a game)

3) **Restricted mediation** (content restrictions, such as prohibiting the use of intrusive and harassing apps)

4) **Monitoring** (observing and monitoring children continuously when using apps)

These four categories can generally be used by parents and teachers in the school environment for children. In this research, sometimes active mediation was used related to the need of helping preschoolers with the management of the touch tablet during using DGBL apps. In the other case, teachers and parents help children when they are confused about how to use apps (such as a guide to show the play button).

2.4 Synthesis of Past Research Findings CT & DGBL

Digital games based on education can help children to solve learning problems. These digital games can also accelerate and facilitate the impact of interaction on understanding educational issues. However, further studies in this area need to clarify the ambiguities in this regard. These include understanding how these games work, new technology, affecting a variety of children's skills. What is highlighted in this chapter are the important implications of creativity and play and how to increase learning in preschool children, and encourage teachers to use these games to teach in a classroom environment to facilitate knowledge transfer to playful young children.

The special feature and specialized approaches of these games are mostly possible by creating a three-dimensional space or other scientific and visual phenomena. A number of educators also believed that if these features of digital games, the ability to reconstruct the real three-dimensional world, were combined with other sciences such as geography, social sciences, history, linguistics, and art, it would enhance children's learning (Grammenos and Antona, 2018).

Teachers also without obtaining knowledge of technology and applications cannot keep pace with the advancement of technology. Therefore, in order to create this knowledge and help students to master the game, teachers need to acquire the necessary knowledge. In fact, teachers need knowledge along with the ability to access the information obtained, and in this way, they can develop children's creative skills. Creativity in teaching methods should also be designed to allow children to be active sufficiently independent (within the principles of education).

DGBL games (due to the attractive digital cyberspace for educational and creative activity) also reduce the extra cost of school for any creative or learning activities in the traditional

classroom and environment, such as scissors, paper, and other materials. However, more research is needed to clarify the advantages and disadvantages of these DGBL games on various educational topics for young children. Therefore, more extensive research is needed to improve learning and creative thinking in young children as children for a better future for these children and to improve their work experience in knowledge-based processes in designing DGBL games (Beghetto and Karwowski, 2018).

Evidence in recent research on concrete play programs on recent digital education shows that existing DGBL programs do not have the right design features to enhance creativity, learning, and assessment grades in preschool. Accordingly, to provide coherence analysis, the positive impact of educational games on creativity and designing a pedagogy scheme is also deemed essential (Leggett, 2017). Hence, this thesis highlights the combination of creativity and learning components in a single model or framework that can have a better movement and impact on strengthening learning in young children. This combination also stimulates children's motivation in the components of creativity and learning.

2.5 Critique of Previous Research

According to data collected from recent studies on the limitations of learning-based digital games, in educational settings and creativity, the biggest limitation of studies is the fact that teachers cannot use the same system for different subjects to manipulate educational and creativity components (lack of interdisciplinary programs). Consequently, if a program doesn't track or display data properly, children may feel frustrated (Zupan, Cankar et al., 2018).

Another limitation is the lack of DGBL curricula and creativity. In order to provide a comprehensive analysis of the positive effect of educational games on creativity and learning, designing a pedagogy scheme for the preschool level is necessary. Evidence suggests that combining the components of creativity and learning in a single model or framework, it may

provide better performance in retrieving learning and creativity for preschoolers (Zupan, Cankar et al., 2018).

The next reported limitation is that young students are overly focused on virtual information, with results suggesting that children are overly attracted to virtual space and images of complex DGBL systems and creative components. Hence, the result of studies for the evaluation of learning in DGBL indicated moderate learning. Besides, assessment courses are very short to assess student performance and learning, requiring longer evaluation and long-term experience. Learning content should be clearly understood for young children and related to learning goals.

Case studies on learning, teaching, and communicating with creativity enhance the needs of specific educational topics to help identify the most appropriate elements to focus on (Zupan, Cankar et al., 2018). More research should be done on the development of creativity in DGBL programs with the introduction of programming so that teachers can easily create and transmit content because the quality of teaching affects the attention of students.

2.6 Framing creative thinking and theory in DGBL design

2.6.1 Creative thinking

According to Vygotsky (2004), creative behavior in young children occurs when playing (Vygotsky, 2004). Therefore, children's play and creative behavior are closely related to each other. Hence, in this thesis, two main frameworks used to identify the components of play and creativity in children when using DGBL. The first framework in defining the themes of creative behavior or practice is “Analyzing Children’s Creative Thinking” the ACCT framework, which is based on Vygotsky's sociocultural theory in guiding the creative talents of preschool children in the real world (Vygotsky, 2004; Robson, 2014). Robson (2014) developed the concept of creative development to define the potential and real development of children in

critical thinking and creative skills. Although the development of creativity can lead children to do things independently, the potential development of creativity can even be related to activities that children do with the help of peers or an adult. This upbringing can be both creative and learning skills that, with the support of adults, lead them to the intellectual maturity of children (Robson, 2014). The potential development of creativity is a very important fact because, according to Vygotsky's theory (Vygotsky, 2004), children may have immature skills in creativity that can be classified as developmental skills through proper training.

It is vital to foster children's creativity at the preschool level in order to identify creative personality and thinking and guide their talents led to Robson's theory of guiding creative talent in children (Robson, 2014). According to the definition of creativity from Robson through the use of “Analyzing the Creative Thinking for Children "ACCT” implies that behavioral or imaginative thought is intended to be purposeful, leading to creative thinking or creative behavior (Robson, 2014). This framework focuses on the process of creativity in children, and in comparison to many common tests, the ACCT framework has simpler content in understanding the behavioral dimensions and the rate of development of children's creativity. Developing creative skills is useful for reading as it provides a framework for guiding childhood educators who are trying to understand the internal and external processes of children's development. Robson (2014) stated that the natural way for children to learn is the ability to use their creative skills through drawing, dancing, painting, language, and music (Robson, 2014). These opportunities help children develop creative and critical thinking skills and become fully efficient people. In this research, the definition of Robson (2014) is used for creative skill and learning, which has happened in a special context in young children. By way of example, when a child carries out a new design on a tablet, his goal is to create a painting, which is a kind of an innovative act. Table 2.6 shows an adapted rubric from the ACCT framework used in DGBL for this thesis (see table 2.6).

Table 2.6: Adapted Rubric from ACCT framework (Robson, 2014)

Types of creative thinking		Codes	Definitions
Exploration	Exploring	E1	Tending to discover the potential of a challenge, activity, or substance
	Engaging in the new activity	E2	Ready to get involved in an activity and coming up with an idea
	knowing what you want to do	E3	Enjoyment of being curious when choosing a game
Involvement and enjoyment	Trying out ideas	I1	Finding a new path, using previous or new knowledge to obtain an idea or hypothesis
	Analyzing ideas	I2	Providing an idea and to make a decision whether or not to pursue it
	Speculating,	I3	Expressing opinions and asking teachers or friends about their activity
	Involving others	I4	Engaging with other children or adults to develop an idea or activity
Persistence	Persisting,	P1	Resistance to the game and enduring the ambiguity of the game
	Risk-taking,	P2	Taking risks and learning from mistakes
	Completing challenges	P3	Believing in own self and expressing a sense of self-efficacy, self-esteem, and the joy of finding solutions to challenges

*Note. Definitions were slightly modified by the author of this thesis and were used to guide the evaluation of aspects of creative skills demonstrated in the artwork. Adapted from Thinking Creatively in Action and Movement for preschool level, based on the ACCT framework by Robson (Robson, 2014).

When children play, their creativity grows more. In fact, it can be said that there is a close connection between creativity and play. Children's play promotes their cognitive development. This is because children's play leads children to acquire new skills, knowledge, and understanding of the world around them. Vygotsky called this activity a "progressive activity" (Vygotsky, 2004).

Meanwhile, there are many classifications and frames for different types of play taxonomy (e.g. Hutt and Gibby, 1979; Caillois, 2001; Bird and Edwards, 2015), but in this thesis, Hughes's taxonomy was chosen (Hughes, 2002). The rationale behind choosing this classification was the existence of both small and large details about the types of games. This classification divides the types of games into about 16 types. Another difference existing in this classification is the appropriate definition of the types of games to be adapted to the virtual world and digital games based on education.

On the other hand, this approach to playing and creativity skills helps the researcher to have a deeper understanding of children's behavior during playing DGBL. This taxonomy can provide a more accurate evaluation by designing and developing ideas and themes and analyzing them.

Therefore, based on the two selected frameworks (Hughes, 2002; Robson, 2014), this thesis has reviewed the thoughtful, and creative action in children. Consequently, in this thesis, for the second framework, Hughes's taxonomy (2002) is chosen. Hughes's taxonomy (2002) is the use of divisions for the classification of play types in the real world. This taxonomy of play types was added to this research due to its complete adaption to a digital environment (Hughes, 2002) (see table 2.7).

Table 2.7: Adapted Rubric from Hughes's taxonomy (Hughes, 2002)

No	Features of playing in DGBL	Adapted definition	Example
1	**Symbolic play**	When children feel from making one piece to another, they create an object or creature like a horse in an application.	*"Mani put a rectangle and a square together and happily said he had built a house."*
2	**Rough and tumble play**	During using a tablet for playing digital applications, when kids are playing with each other cooperatively and energetically.	*"Olivia and her friends take paint with each other. They complete the painting with great energy."*
3	**Socio-dramatic play**	Real-life scenarios.	*"Max imagines himself as a pet doctor and wants to treat animals with an application (Toca Boca nurture)."*
4	**Social play**	A digital game that has rules for interacting and encouraging social interaction.	*"Playing a group of kids to build a simple building with simple squares, where the tablet is passed from one child to put square to another child to put the next square.*
5	**Creative play**	A digital game that takes children to explore and develop ideas and things.	*"Ian was encouraged to build a building from the main shapes (such as triangle, circle, square, rectangle) by an application and Ian says with excitement and joy. "Look, I've built a house."*

Table 2.7: *(Continued.)* Adapted Rubric from Hughes's taxonomy (Hughes, 2002)

6	**Communication play**	Play with words, songs, rhymes, lyrics, etc.	*"Mani played with the rhythm of words, poetry, etc. in a digital environment"*
7	**Dramatic play**	Playing for performances that are not directly on television	*"Yu Xin without practicing reality plays a role in the digital environment rather than a character (such as television shows).*
8	**Deep play**	A digital game that involves moving, for example, chasing, hiding, and searching	*"For example, the game character was hidden somewhere in the digital game environment and the child had to find that character when playing."*
9	**Locomotor play**	The child is faced with challenging experiences in that he/ she feels it is necessary to find for survival.	"*The digital play where the child is confronted with the challenging play which character of application has to do risky things to survive."*
10	**Exploratory play**	Children play all their senses by searching for objects, spaces, and so on through the information available in the game.	*"In digital space of games, in which children search and discover objects, environments, etc. in cyberspace through the information gained in the game."*
11	**Fantasy play**	Children's role plays that do not exist in real life, such as superheroes.	*"in applications where the child was identified and screened by a character on the screen and engaged in the activity."*
12	**Imaginative play**	Playing with children in a way that pretends to be something else.	*"Lela used a circle shape as an apple fruit to feed the digital game character!"*

Table 2.7: *(Continued.)* Adapted Rubric from Hughes's taxonomy (Hughes, 2002)

13	**Mastery play**	Playing in an environment where the child tries to control all the components of that environment and tries to rebuild it.	*"Mani play with Lego application and put spice together by controlling and then building."*
14	**Object play**	The child is ready to play with objects that involve the child's sense of touch and vision.	*"Children will see the digital game and its environment and use their tactile sense by placing their fingers on the tablet screen."*
15	**Roleplay**	Children playing in personal and domestic roles is not considered to be a major role.	*"Olivia played a supporting role in the main character in an application and must be equipped with the main character or contribution to help him or her win."*
16	**Recapitulative play**	Children playing in a game where they may discover rituals with myths, history.	*"Maxi gain access to the early stages of human evolution in a digital gaming environment."*

*Note. Definitions were slightly modified by the author of this thesis were used to guide the evaluation of aspects of play skills demonstrated in the artwork for preschool level, based on Hughes's taxonomy (Hughes, 2002).

Hence, Robson's approach includes Hughes's definition of creative thinking and creative action, "a game that enables children to explore, develop ideas and things" (Robson, 2014). Hughes (2002) with designing a taxonomy of play types stated that children's ability to interact in games creates a warm and supportive environment for the development of their creative skills. In this environment is children can effectively learn and communicate with peers. Through these creative interactions, children become more aware of their inner world. Hughes also said that children's play affects their abilities and boosts children's self-confidence and imagination (Hughes, 2002)(see table 2.7).

2.6.2 Technology

Digital technology, used to develop children for special occasions such as education, can also stimulate the imagination in children. For example, body games based on characters or game narratives that attract children's attention in video games or in the virtual world. Children enjoy playing with digital toys and the like, such as tablets and smartphones (Ofcom, 2017). This study also examines the practical role of this technology in enhancing creativity and its relationship with learning. New tools in digital technology may lead to significant advances in creativity and divergent thinking in educational settings for students and the younger generation. However, it is unclear how this tool can have the capability in thoughts and actions against children (Lanna and Oro, 2019). Some researchers call learning and encouraging creative thinking through new technologies in digital environments a "new system for understanding the creative process" (Spendlove, 2008; Lewis, 2009; Gangadharbatla, 2010).

2.6.3 Digital game-based learning principles intervention

Since in this thesis, investigating the effect of digital learning-based game space on learning skills and its relationship to the stimulation of creativity and play are seek. Several frameworks in this field were also examined, including those provided in detail by the National Research Council (2019) or those provided by Gee (2007), Durga (2009), Prensky (2003), and Malone (1981) (Malone, 1981; Prensky, 2003; Gee, 2007; Durga and Squire, 2009). The principles of creative based learning (CBL Model) of Bellotti (2010) and the principles of creative education (ARCS Model) from Keller (2000) were also examined (Keller, 2000; Bellotti, Berta et al., 2010). Then these principles in a single framework were collected and selected as shown in table 2.8, to examine and evaluate these factors and their relationship to the extent of learning and fostering creativity in the digital environments of DGBL games (see table 2.8).

Table 2.8: Principles of digital game-based learning (DGBL)

DGBL Principles	Purpose / Outcomes
Inspiration	The learner is motivated to perform self-evaluation and self-regulated learning.
Personification	Each learner develops a personal learning strategy and creates his or her learning environment while playing.
Gamification	Learning, as a game and using game thinking to solve problems.
Attention	In the beginning, student's early attention to the game is increasingly important. This can be achieved by engaging in a query in which students have to give examples of problems related to their learning goals.
Relevance	Students' new knowledge aligns with their prior knowledge.
Confidence	If students feel that they are reaching what they are learning goals, they will gain more self-motivation and confidence.
Satisfaction	Satisfaction occurs when the student understands that learning outcomes have real values that they can use in other contexts.

Creative learning principles (CBL Model) and creative teaching principles (ARCS Model) theory were also used as conceptual frameworks because these provide teachers with the skills that can identify and support creative talent. In order for teachers to be able to support creative skills, they need to know how to identify the characteristics of creativity among young children. Bellotti (2010) argued that creative skills can be assessed through "Inspiration, Personification, and Gamification" (Bellotti, Berta et al., 2010). Bellotti (2010) stated that

assessing students' creative skills is an essential step in identifying the ability of young students to be key elements in their development. Involving children in creative activities allows the child to gain more inner self-awareness and inner feelings. In this way, they can more easily express their inner desires to teachers (Bellotti, Berta et al., 2010).

Teachers while performing these activities for children, can accompany them and facilitate the process of creative thinking in children. Children should feel that their creative activities have been noticed and supported when playing in DGBL digital environments. In addition, children should be able to express and implement their creative ideas effectively and easily in a digital environment. The role of teachers is also very important in this regard because teachers should help children develop their creative skills by encouraging them to perform their experiments and assumptions in a digital environment (Keller, 2000). Therefore, learning is said to be applicable under the influence of teachers' creativity in teaching, children's interactions with the digital world, teacher guidance in developing children's creative skills. Hence, by fostering creativity, children's learning skills are strengthened with the support of teachers.

What plays an important role in children's sense of power and self-esteem, and consequently raises the level of children's learning, is actually nothing but doing creative activities and nurturing it in children. In this way, children can easily express their inner desires (Wilson, Barnes et al., 2020). Therefore, considering the above principle, this thesis shows the relationship between the components of creativity and its connection with learning principles about digital in order to raise the level of learning (Figure 2.1). Furthermore, this figure shows how the presence of teachers in strengthening and creativity and communication with children, how to increase the level of learning in the digital environment. Teachers and parents' supporting when the child is involved in digital education-based games can foster instructional skills, creativity, divergent and computational thinking, and critical thinking. This thesis seeks to find out how children's level of learning develops under the influence of their creative skills

in a digital game-based learning environment. Therefore, figure 2.7 is presented to show the role and relationship of three creativity components of Robson's framework with learning STEM (science, technology, engineering, mathematics) based on the STEM curriculum outline for the preschooler (Robson, 2014) (Ministry of education, UK, 2017-2027) (Wilson, Barnes et al., 2020) (see figure 2.7).

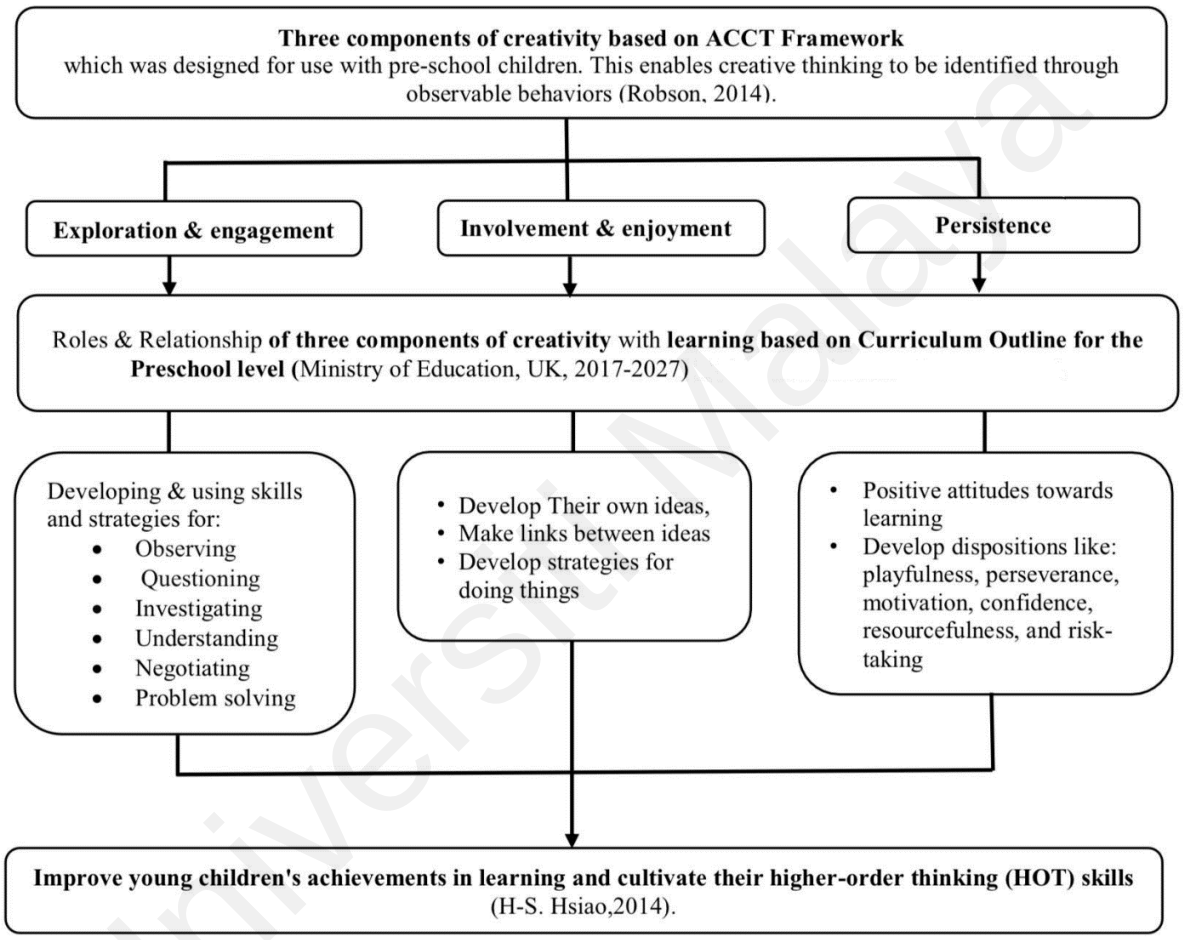

Figure 2.7 : A theoretical framework for fostering creativity that enhances learning in DGBL.

2.6.4 Role of teachers and parental engagement

Teachers and parents shape the interaction of children with technology. It should be noted that the experiences of teachers and parents in this area are important and can be examined.

Another factor that can affect data analysis is the values and beliefs of teachers and parents, which have a direct impact on children's perceptions when using digital games.

For example, participant (5)'s Mother said:

"I talked to him that having a balance in touch tablets and smart cellphone usage is very important, and children should be taught how much to use on a tablet every day, even though the use of the tablet in the learning path."

Although the parents were concerned about the negative impact of iPad on their children's continued use for digital game-based learning, they did see their child grow in a wide range of learning skills, creativity, social and personal skills. Parents and teachers were more trended with the balance between using digital games alongside children's physical games in the real playground environment. Teachers and parents have provided a wide range of information to this research when they viewed children while using the tablet. They also pointed out that children were randomly attracted to apps that focused on both entertainment and learning.

Participant (6)'s Mother said:

"My daughter was very excited when using an app. However, I did not teach her before, she knows how to click on to make juice of fruits to mix, and this shows that these games unconsciously entertain children through education."

In this research, one of the issues regarding the use of preschool children's apps has been their tendency to be independent in using games and tablets while children need help from parents and teachers to play with tablet apps, especially with unfamiliar ones. Yet what has been reported indicates the desire of preschool children to play in an independent way. Teacher 2 stated:

*"When **participant (3)** was playing with tablet apps, I was showing some icons and guiding him with my hand, while he was holding my hand. He insisted that he could play alone."*

This case has been reported by other teachers for other children tested. However, it can be said teachers in many cases have cooperated and supervised so that the student permits, and this is different in terms of monitoring the use of interventions.

In addition, this research sometimes used active mediation that is related to the need to help preschoolers about the management of the tablet. This mediation is mostly used in managing the time of using the iPad and programs through teachers and parents. When this is the case, the child is unable to control the amount of time he/she uses the iPad. Or, another case is when the child has difficulty using the game menu. For example, it is when the kids do not know which button to touch to start the game. This is an example of strategies by which teachers and parents can help their children and students manage their tablet and apps more effectively. By way of example, one of the teachers reported:

*"I had to remind **participant (6)** to press a special button to use one of the apps."*

Therefore, teachers play an important role in nurturing children's creative talents. Teachers' involvement is also important in fostering creativity when children use educational-based digital games (Clark and Teravainen-Goff, 2020). Children should feel that their creative aspirations are recognized and supported when using digital games. Children need to be able to express their inner desires effectively when implementing their creative ideas (Nikken and Jansz, 2014). Teachers also support children in this process of fostering creativity by encouraging them to experiment and make assumptions. In addition, teachers, along with digital games, can nurture children's creativity in areas such as math, science, etc. Teachers and parents make digital games interact faster with the world of children. In this thesis, the role of applied theories and the value of the presence of teachers and parents with their children

when using DGBL games are also examined. What has a direct impact on children's interaction with digital media is also the beliefs, convictions, and values of teachers. Figure 2.8 shows the intersections of the role of teachers and parents in the conceptual model presented in education-based digital games (see figure 2.8).

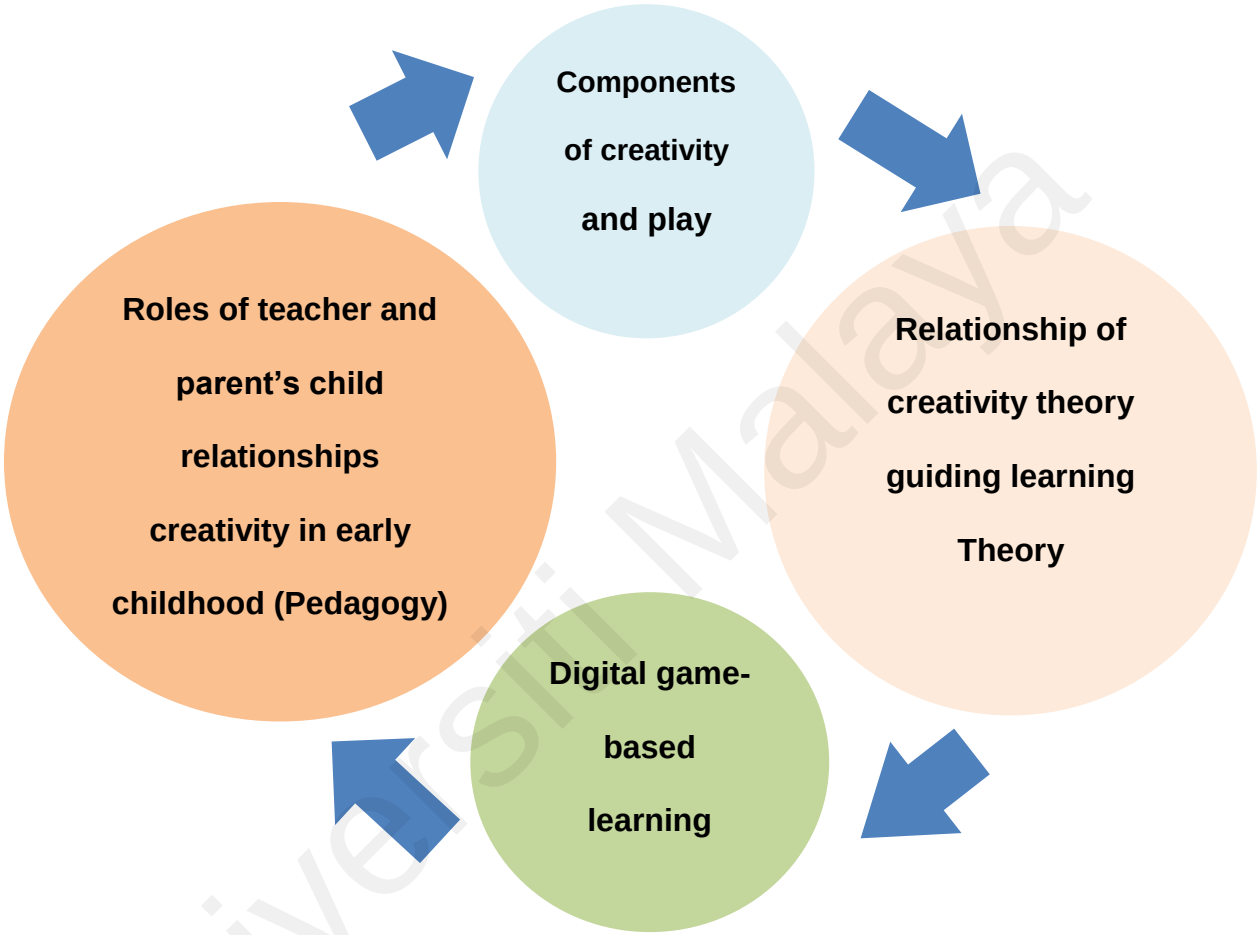

Figure 2.8 :Intersections of elements in the conceptual model of DGBL

2.7 Proposed Initial Model in DGBL applications for Preschooler

Therefore, based on the selected frameworks (Hughes, 2002; Robson, 2014), and the principles of creative-based learning (CBL Model) of Bellotti (2010), and the principles of creative education (ARCS Model) from Keller (2000), the initial model in DGBL applications

for preschoolers was proposed in this thesis (Keller, 2000; Bellotti, Berta et al., 2010). These components from these models and frameworks in a single framework were collected and selected as shown in the figure 2.9 to examine and evaluate these factors and their relationship to the extent of learning and fostering creativity and play in the digital environments of DGBL games (see figure2.9).

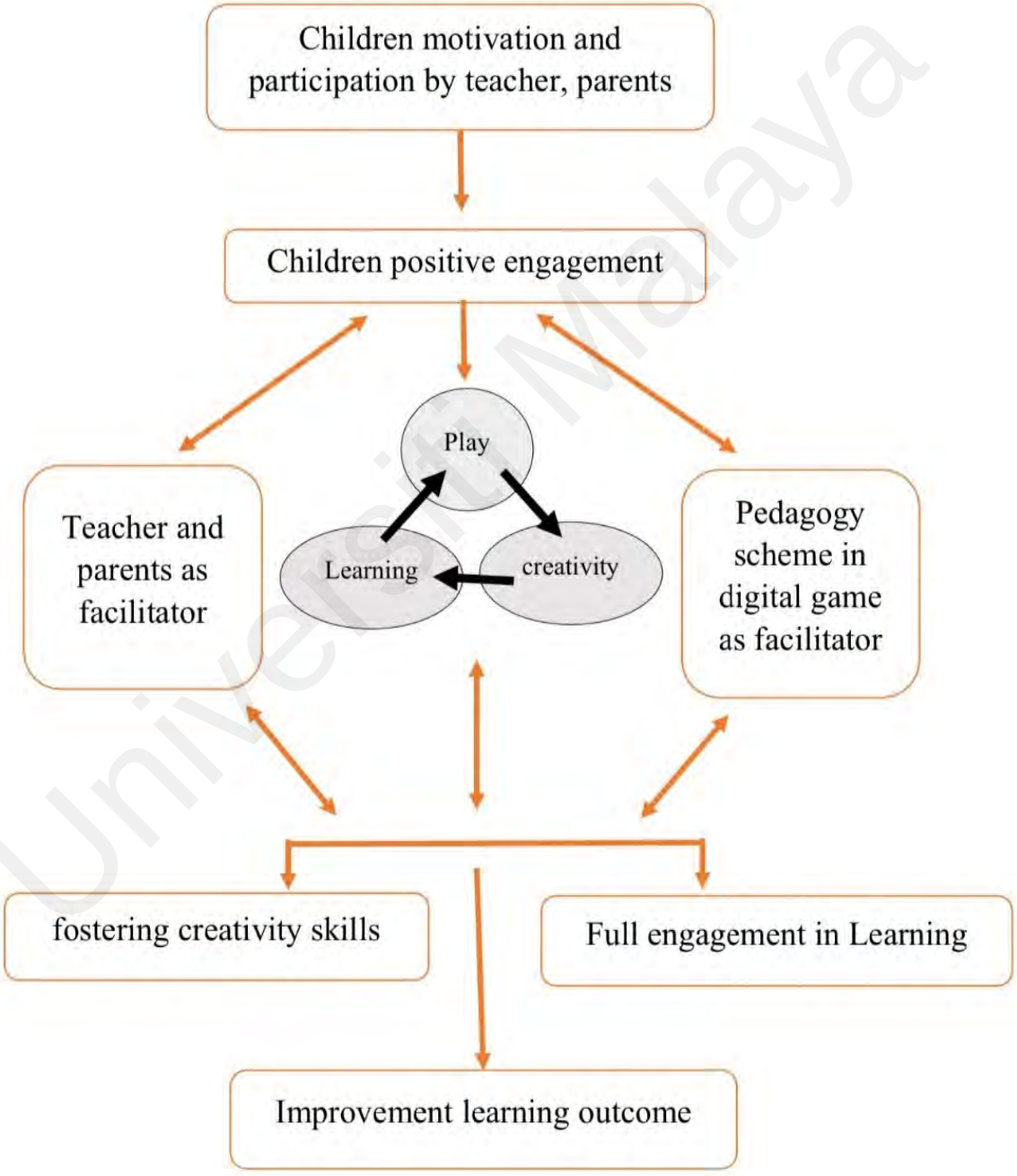

Figure 2.9: Proposed Initial Model in DGBL applications for Preschooler

In addition, as mentioned earlier teachers and parents make digital games interact faster with the world of children. In this thesis, the role of applied theories and the value of the presence of teachers and parents with their children when using DGBL games are also examined.

According to all the components and theories that were used in this study, on the basis of the proposed model, a simple prototype of digital games based on STEM training (to be mentioned in Chapter 5) also has been designed. The flow of this prototype is shown in figure... based on the initial proposed model (see figure 2.10).

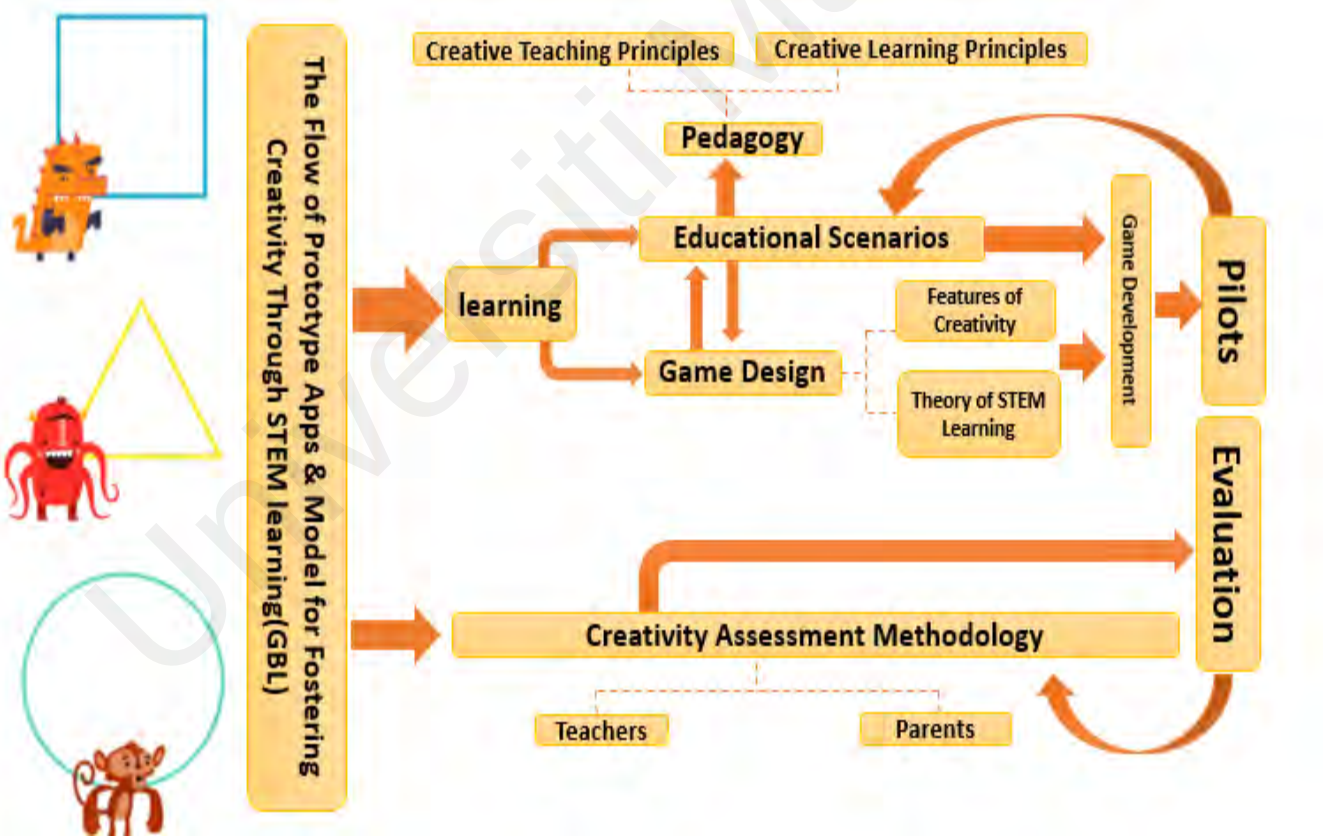

Figure 2.10: The Flow of Prototype, Model and Pedagogy

2.8 Summary

This part of the thesis examined studies conducted in the field of digital games based on education and creativity. The age range for these articles is preschool and typically three to six years. This chapter explores the literature on preschool applications for creativity and learning. It also describes the definition of creativity and games associated with learning and its main aspects. This chapter reviews the existing models/frameworks and their limitations and then investigates the techniques used in existing applications to support children's behavior in developing creativity and raising their learning levels and describes the existing gaps. This chapter discusses the limitations of these studies by examining the depth of existing and similar studies.

This chapter demonstrates that DGBL can (in the near future) provide a variety of subjects for young children by engaging, interacting, and motivating children regarding learning and creativity. Further studies and evidence are needed to determine the effectiveness of DGBL in fostering learning and creativity compared to traditional teaching methods. Besides, further research on RTC and longitudinal studies in a specific environment for young children is needed. Many researchers also highlighted the problems as a lack of using a specific framework and model DGBL apps for fostering creativity among young children. Most of the studies on DGBL apps by using tablets addressed fostering creativity and enhanced learning as two separate tasks that utilized different frameworks. However, these approaches faced the problem and recent evidence on game apps demonstrated fostering preschoolers' creativity through these applications has not been successful to assist young children to enhance their learning. This chapter is important and useful for researchers and game designers, technology developers in the field of video game-based preschool learning.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

This chapter explains more about the method and implementation used in the experiments of this thesis. This chapter also discusses the techniques and procedures used to analyze data, participants, and behavioral and ethical analysis for young children in the creative skills and learning process. These include interviews, video recording, checking, and evaluating experts.

In this research, the development of creative thinking skills and related activities were examined. As mentioned earlier, the method used in this study is a case study. According to Hancock (Hancock and Algozzine, 2017), a case study involves an empirical investigation of a new siege phenomenon in a natural, calm, and stress-free environment. The cases studied in a case study can include Companions, curriculum, and events (Hancock and Algozzine, 2017).

In a case study, instead of proving the hypothesis, the researcher seeks the main behaviors and events and identifies themes. The advantage of the case study method over other research methods is that it has access to a wide range of real events, documents, observations, and interviews (Yin Robert, 2017). Therefore, as previously mentioned, this case study also includes observations and interviews with teachers, parents, and children at the preschool level, the necessary works, and documents related to them.

3.2 Research questions

As mentioned earlier, the focus of this study was on training and required skills and learning areas based on digital games and learning concepts and programs while developing creative skills in these programs, especially in STEM at the preschool level. The research questions dealt with in this study are:

RQ 1: What are the strengths and limitations or gaps of existing models and frameworks of DGBL for fostering creativity approach preschoolers to better learning STEM?

RQ 2: How can a model of digital game-based learning be developed to enhance creativity among preschoolers to better learning STEM?

RQ 3: How can a prototype of a digital game-based learning STEM app for preschoolers' level based on the proposed conceptual model of the DGBL app enhance creativity and achieve better academic skills for preschool level?

RQ 4: What are the effects of the proposed model of the digital game-based learning app on creativity and learning STEM among young children?

3.3 Purpose and Design of Study

The purpose of this study is to focus on examining the level of children's learning in the STEM department by cultivating the components of creativity in the DGBL virtual play space. The test was performed on preschool children in Malaysia.

In recent studies, the best methods for teaching computer science and new DGBL technology among young students have been based on research by scholars such as Hazzan (2015), Yadav (2016) & Harteveld (2014) (Harteveld, Smith et al., 2014; Hazzan, Lapidot et al., 2014; Yadav, Berges et al., 2016). However, very little research has been done on these digital games and their impact on preschool children.

One of the most important reasons is the lack of awareness, skills, and acceptance of teachers and parents in the use of DGBL games and digital technology. These reasons subsequently prevent the implementation of DGBL technology and games at the preschool level in schools. In this case, qualitative study, qualitative data collected through watching

videos, interviews with teachers and parents, and other documents are used to understand the skill level of children aged between 3 and 6.

In this thesis, gathering the experiences of teachers and parents was very helpful for the researcher to find the most effective components of creativity in learning in the field of DGBL. Observational notes, video recordings, interviews with teachers and parents were collected to understand children's behavior and the relationship between creativity and learning.

In the reviewed literature, research in this field included both qualitative and quantitative research (Nelson-Walker, Doabler et al., 2013; Smith, 2014, Novak; 2015). Quantitative studies have often examined how digital games affect the development of children's skills. However, the direction of these studies in examining the rate of skill development and its relationship with other abilities of children is unclear.

Qualitative studies also focused on the development of children's skills and the professional development of teachers (Skourdoumbis, 2014; Green and Allen, 2015; Rahmatullah, 2016). A case study was done by Yin (1994) in terms of the research process as "empirical research that examines the contemporary phenomenon in the context of real-life"(Yin, 1994). While Yin focused more on the research process, Stake (1995) focused on the research unit. Stake believes that a case study includes "both the process of learning and the product of our learning" (Stake, 1995).

A case study has been described by Merriam (1988) in terms of the final product as "a comprehensive descriptive qualitative study of a sample, phenomenon, or social unit" (Merriam, 1988). Each definition has a unique perspective on what defines a “case study” provides, however, allows the researcher to understand the parameters and focus on what studies should define.

Table 3.1 : Describing the instruments

Instrument	Instrument detail	Output	Process
Observations (manual and video)	The observations were made based on a case study. The researchers looked at children who were using games based on digital education, and when children stopped playing, the researcher stopped watching. Access observations were made in accordance with parental permission and moral satisfaction, and video observations were made in a location with facilities and similarities to the Montessori school preschool. A monitoring schedule was also created to facilitate the process and ensure that all relevant data was recorded.	An extensive narrative was provided in the process of creative development of children and their learning rate in games based on digital education from the researcher's point of view.	• The research was done in a similar environment to Montessori Kindergarten and Preschool. • Selection of children and monitoring of their continuous flow in the conflict with digital games to collect data. • Data collection, monitoring, and research-based activities were performed by the researcher.
iPad and digital game-based learning applications	A semi-structured interview was used to questions for the children. The table questionnaire contains several open questions that produce qualitative data and several closed questions that provide semi-metrics. In the first phase, on nine of the occasions (top effective nine educational games), the author recorded and the teacher was presenting to the children. The apps were introduced to children and, then children were recorded during using the apps. The children were recorded when using apps sometimes chosen by themselves but at times they were directed to specific apps by the researcher and teachers.	Children and teachers' perspectives were recorded and their creativity and justification for creative decision-making help to enhance learning.	• The children used the iPad during digital games, which was another source for the researcher's research on the impact of technology on creativity and learning.

Table 3.1: ***(Continued.)*** **Describing the instruments**

Researcher-led activities	The children's participants were observed in four different structured activities: 1. DGBL and creativity skills 2. DGBL and play 3. Principles of GBL apps and learning 4. Difficulty of the use of games.	The children's observation and videos provided an insight into their preferences and decision making around their creativity skills, play, learning, and overall design of DGBL resources.	• Data were monitored and collected within ten days. • Simultaneously with the children's play, the time of use and selection of digital games was considered by the researcher.

This research should have boundaries so that it can define what will happen and be studied and allowed it to pay attention to it. This thesis has done "Experiment one" based on (ACCT) framework (2014) and Hughes' Play Taxonomy (2002), interviewed and observed the type of creative activity, creative thinking, children's play and, game difficulty (Hughes, 2002; Robson, 2014).

As mentioned in previous section, this research investigates the pedagogy principles of creative teaching and learning apps based on the observation CBL model and ARCS model. As shown in table 3.1, children were observed in four different structured activities: (1) DGBL and creativity skills, (2) DGBL and play, (3) Principles of DGBL apps and learning, and (4) Difficulty in the use of games (see table 3.1).

In experiment two, like the "Experiment one" procedure, the proposed model of game-based learning and creativity (STEM) and simple prototype are presented and investigated. The interview and progress of young children in learning based on digital games and their inferences and recommendations were based on these results. This thesis, being qualitative, is more descriptive in nature.

3.4 Evaluation Methods

In most recent research for young children, the quantitative method has been used. However, there is little evidence of the qualitative approach to investigate children's behavior (Brooks and Sjöberg, 2020). The qualitative methods especially "case study" for investigating the behavior of young children are very important (Brooks and Sjöberg, 2020). The reason for the importance of using this method in several recent researches in comparison to the quantitative method is to provide a deeper understanding of the interviewees' behavior in different dimensions and the interaction of the phenomenon in question (Brooks and Sjöberg, 2020). This involves reading through field notes, listening to interviews, or watching videos to identify themes and repeat ideas that will help find research questions (Rossman and Rallis, 2011). Researchers need a way to translate these interviews in a simpler way for analyzing and classifying. Therefore, open coding at this stage helps the researcher to simplify the data set. A comparative approach within the data set is used to identify the themes and patterns within them to organize the data. The next method is numerical coding for participants' responses. These themes within the collection help the researcher get closer to the structure and framework the researcher has in mind. Strauss and Corbin (1998) introduced axial coding for interview data (Strauss and Corbin, 1998). Each code represents a specific dimension of the analysis that gets closer to the hypothetical framework by interacting with other derived codes (Saldaña, 2021). Thus, in this research, the qualitative data collected from the interviews and the films were analyzed, and then each version systematically utilized theoretical analysis to allow this thesis to reach a central theory (Hatch, 2002; Creswell, 2021).

This dissertation has five separate phases which are shown in figure 3.1. These steps address the research questions (see figure 3.1).

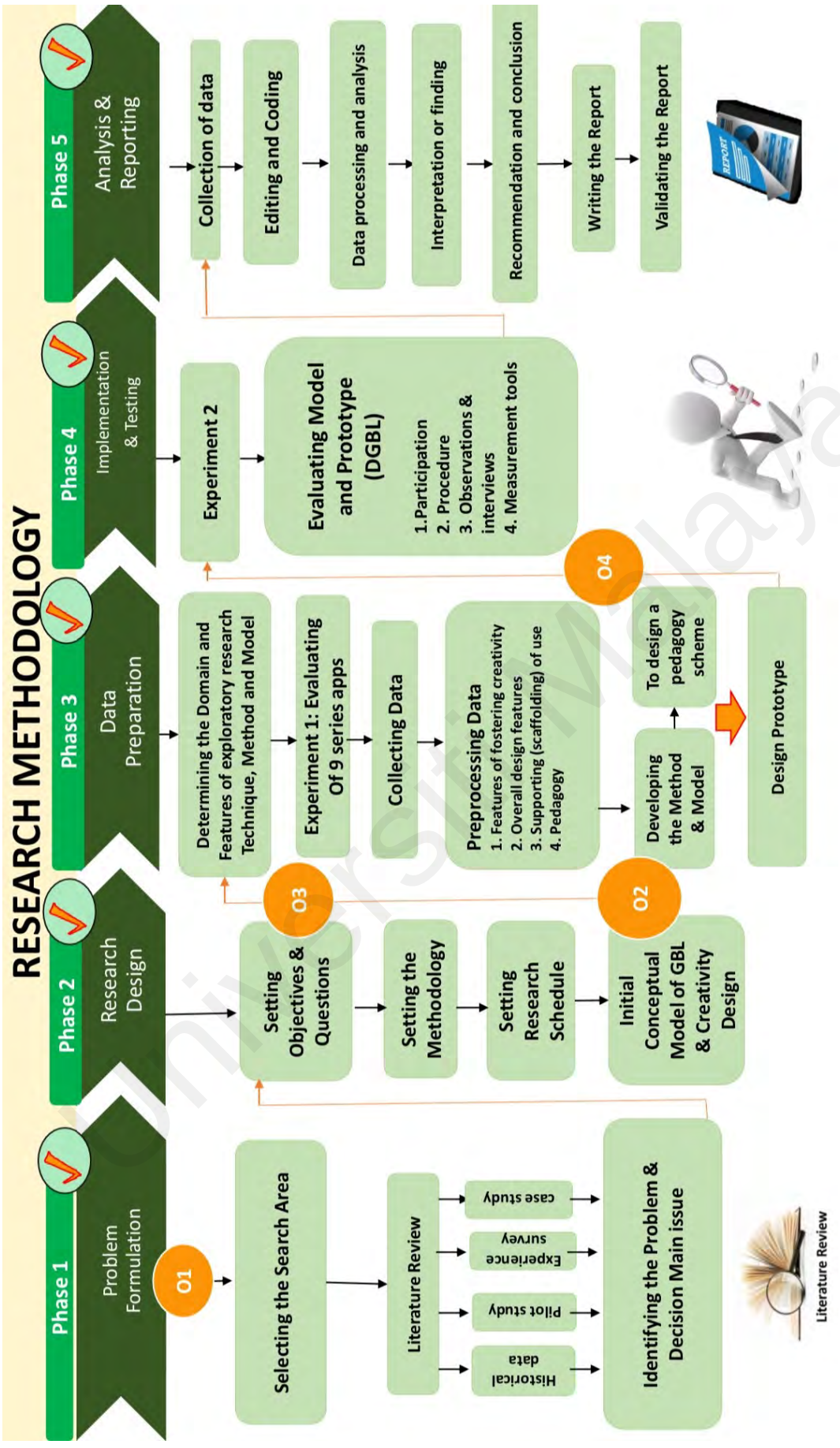

Figure 3.1: Methodology

3.4.1 Phase 1 and 2

This phase was going to address objective one that to identify and compare existing models and frameworks in order to find features of creativity and provide an initial conceptual model of DGBL based on fostering creativity for preschool level. In this thesis, systematic analyses of the literature of studies regarding using of DGBL, along with the use of technologies such as tablets and smartphones, to improve creativity in preschool children have been performed.

The findings were analyzed using PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) principles. The process of coding and classifying the desired and defined categories occurred at the time of reviewing the articles. The research methods used were different in the reviewed articles. Then, from the general results, the main themes were extracted and presented in the findings section of this study. This phase includes a review of existing models/frameworks and their limitations, followed by investigating the techniques used in existing applications to support children's behavior in developing creativity and raising their learning levels and described the gaps in it, especially on preschool level (3-6 years old).

As shown in figure 3.2 searching for data for DGBL applications and fostering creativity was collected from online databases IEEE Xplore, Science Direct, Web of Science, Springer, and Scopus. These sources are well known as the largest database, library research, and documentation. Also, this thesis aims to enhance the quality of studies in the literature review thus the search was confined only to journal articles. Articles chosen in this study were intended to be only in the English language while journals in other languages were removed. This phase covered Research Question 1, and these objectives as follow as bellow (Figure 3.2):

RO 1: To investigate and identify features for fostering creative thinking through DGBL apps.

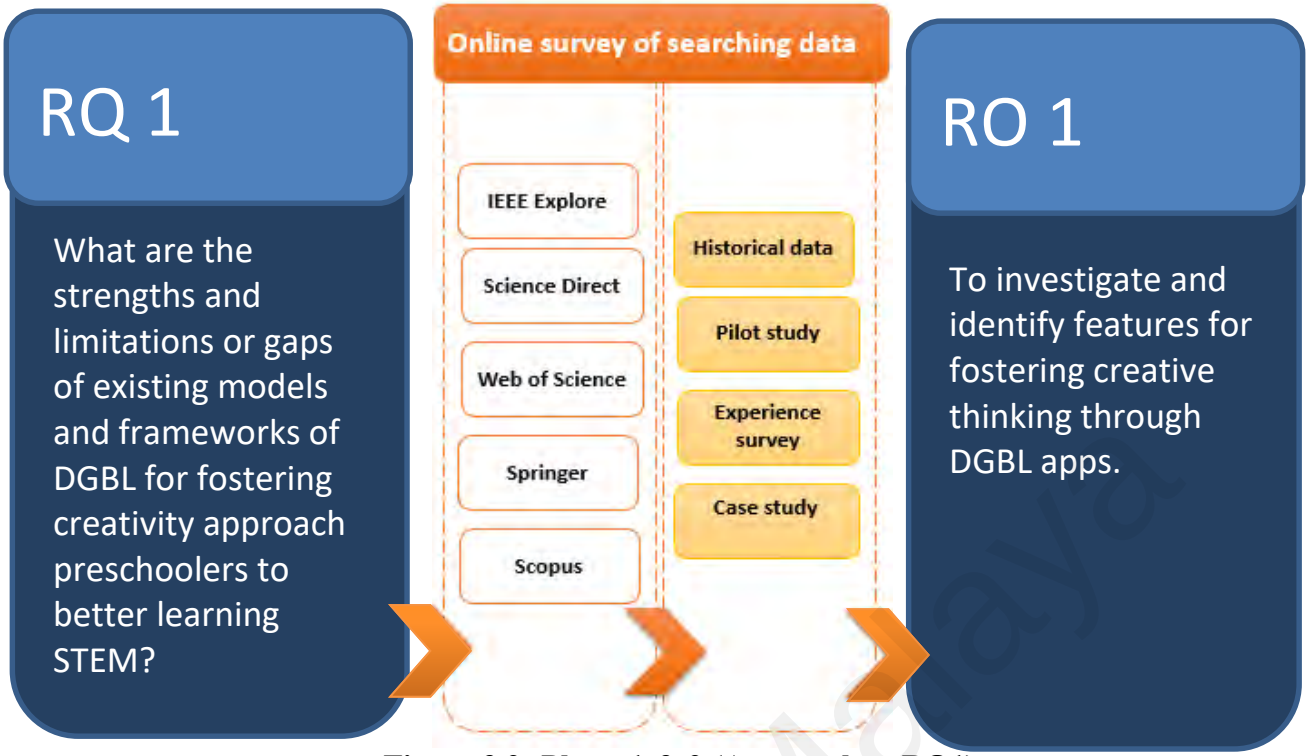

Figure 3.2: Phase 1 & 2 (Approach to RO1)

3.4.2 Phase 3

This phase addresses objective two and three that to determine the domain and features of exploratory research techniques, of existing methods and models popular DGBL apps in order to find features of fostering creative thinking, top nine effectives existing DGBL apps were evaluated (Experiment 1). This phase covered Research Questions 2, and this objective as follow as bellow:

RO 2: To develop a model that integrates content, behavioral, and applying components of creativity, roles, and relationship with learning in DGBL apps for preschool level.

This phase describes the findings from the first experimental interview. This phase in chapter 4 explains how to encourage young children to play digital educational games on tablets and determine these features and components of creativity. The relationship between these components was also examined. This qualitative study aims to discover the components of fostering creativity and learning skills in DGBL at the preschool level. In this present case

study, seven participants in the preschool level (aged 3-6), two teachers, and seven parents were examined in Malaysia affiliated to Montessori school.

At the beginning of this phase, methods, examples, and cases used for studies are described. In chapter 4, this thesis provides an explanation of the participants in the method of researching and analyzing the data collected from semi-structured interviews, observations, and development artifacts. The findings are summarized prior to providing data and results. This is followed by summarizing the data and results. According to contents were founded in the results of data, the findings are divided into the following sections; 1. DGBL and creativity skills, 2. DGBL and play, 3. Principles of DGBL and pedagogy in applications, 4. The difficulty of the use of games (Figure 3.3).

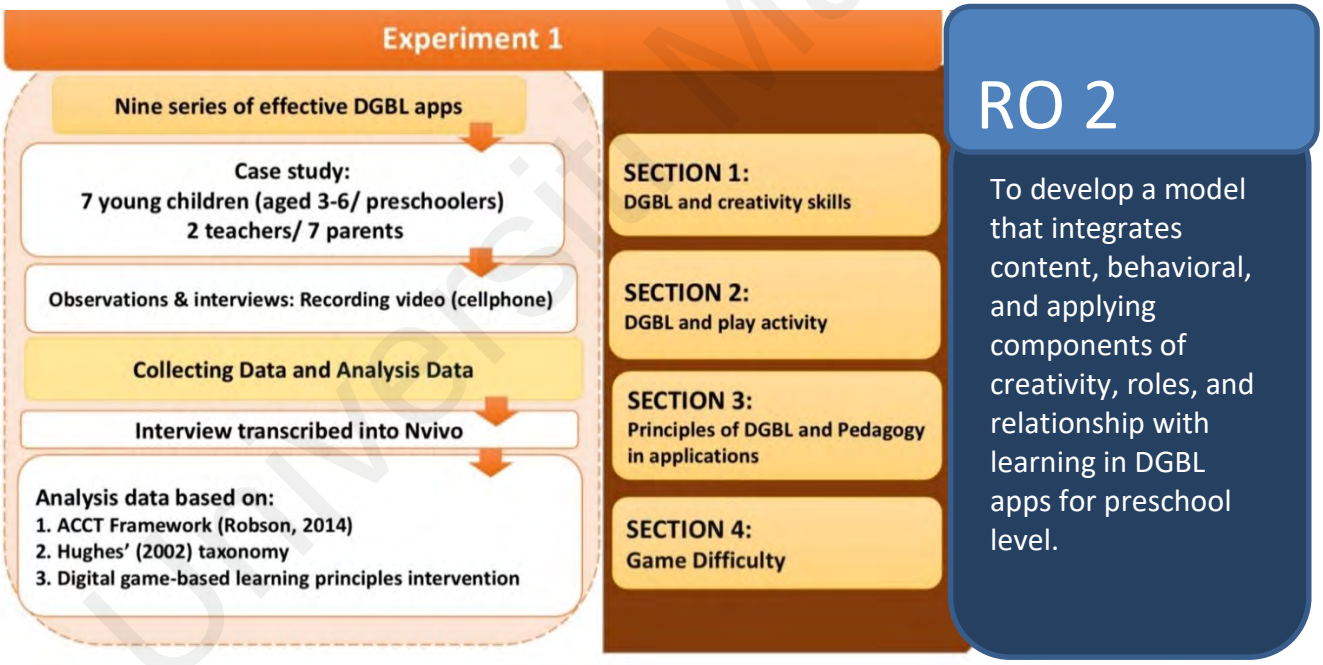

Figure 3.3: Phase 3 (Approach to RO2)

As shown in the figure 3.4, in the first stage, the types of creative activities and applications that children use as a creative activity were discussed. This was done after discussing all aspects of creative thinking based on the ACCT framework (Robson, 2014). In the second part,

according to the characteristics of the game in classifying the factors influencing the development and strengthening of play and creativity in children, it was considered based on the classification of Hughes (Hughes, 2002). Afterwards, in Section 3, the principles of digital game-based retrieval, including creative teaching and creative learning, were examined. The fourth section also describes the difficulty of using games (see figure3.4).

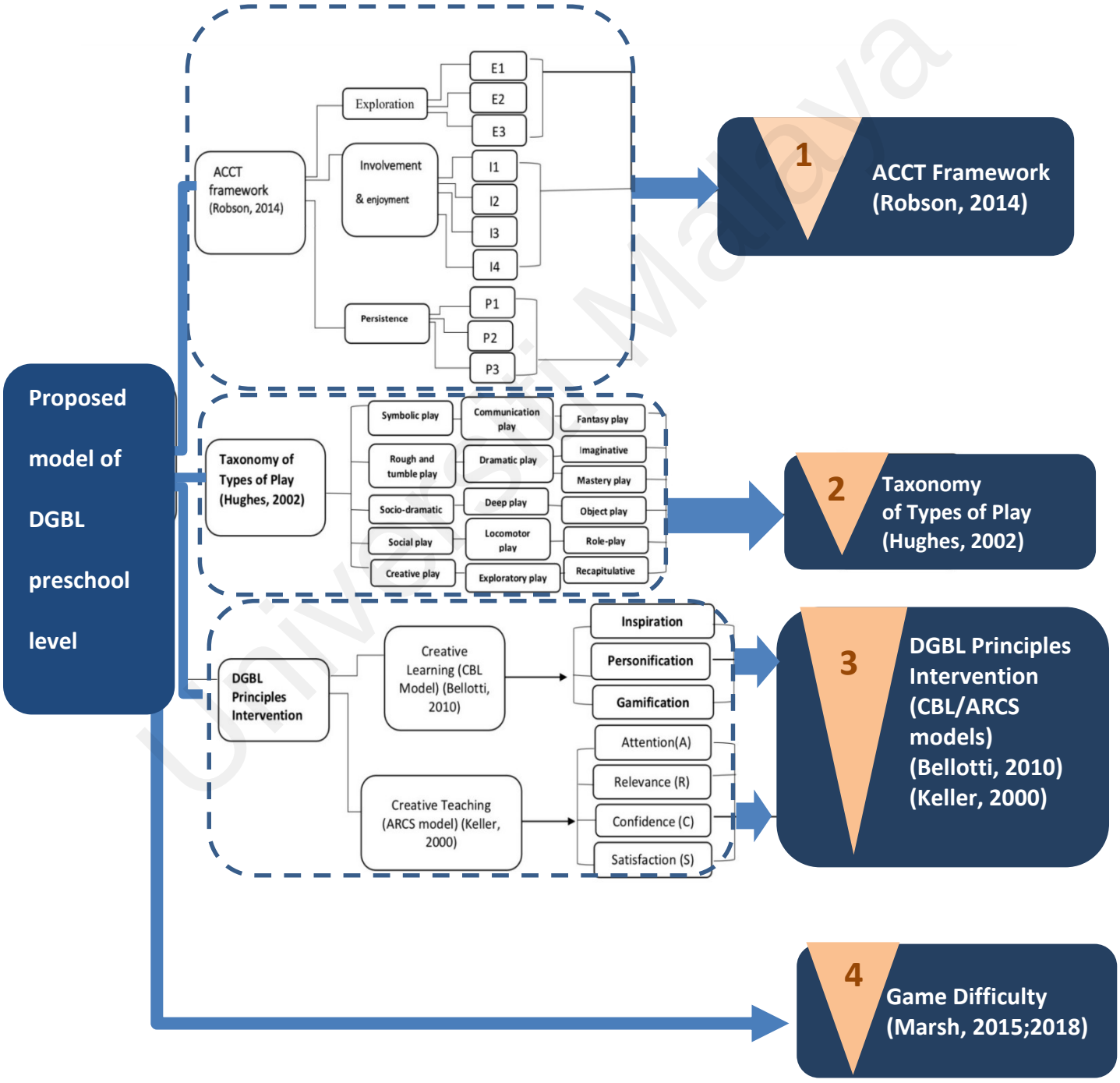

Figure 3.4: Proposed model of DGBL preschool level

Interviews were transcribed and analyzed by using the inductive analysis model in Nvivo. Also, the observations were analyzed using typological analysis. Throughout the process of analyzing the data from these sources, patterns began to emerge and were sectioned into codes (see figure 3.5).

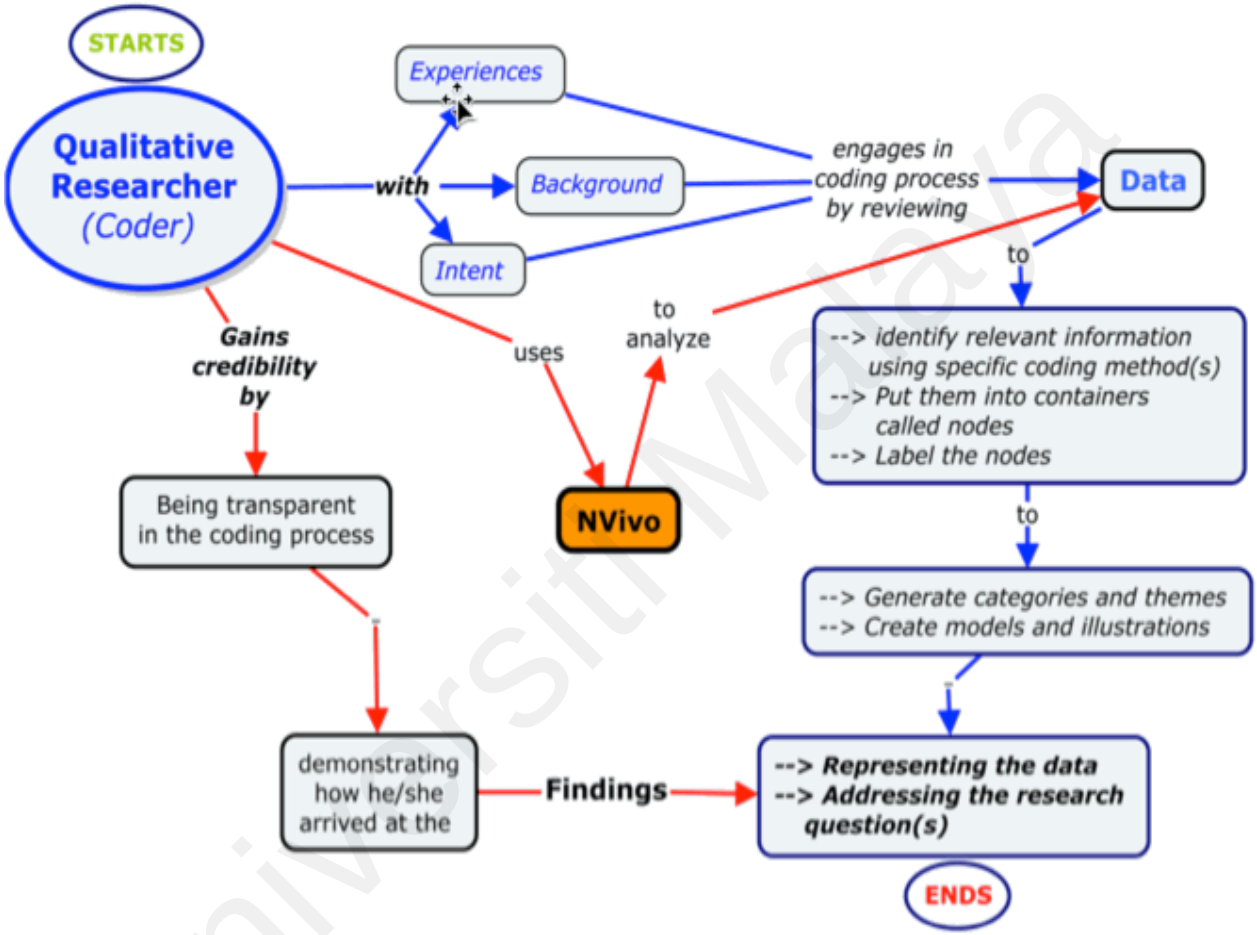

Figure 3.5: Qualitative analysis presses in Nvivo

3.4.3 Phase 4 and 5

These phases addresses objectives 3 & 4 and Research Questions 3 & 4 that to develop that a conceptual model and related prototype were proposed and evaluated.

This phase describes the findings gathered from the second experiment interviews. The proposed model was modified by identifying the valid features of creativity and playability to

be fostered in children. Although the procedure of this experiment is similar to experiment (1), in this phase, to prove the proposed hypothesis based on the proposed model once again, a simple prototype of a STEM-based learning application was designed, implemented, and evaluate. The participants recruited in this experiment (2) consisted of students affiliated to Montessori preschool, too. The procedure used was a case study. Data collection, as well as data analysis, was provided by interviewing respondents among young children, consisting of four sections: Section 1: Observation of Principles of DGBL in the proposed model (components of pedagogy and STEM); Section 2: Observation of the type of creative thinking based on the proposed model; Section 3: Type of children's playing activities based on the proposed model; and Section 4: Game difficulty (see figure 3.6).

Then phase 5 is analysis and reporting of collecting data.

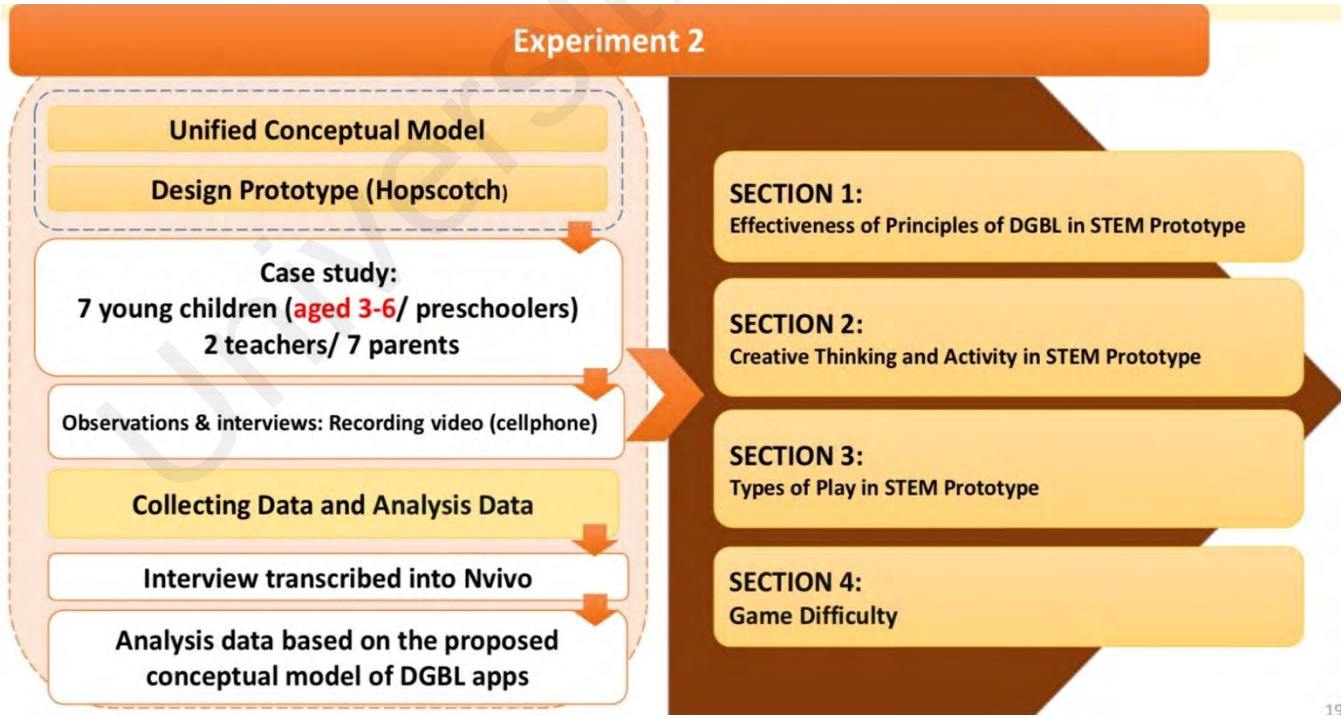

Figure 3.6: Phase 4 (Approach to RO 3 &4)

3.5 Qualitative case-study methodology

A qualitative case study methodology was chosen for this study to enable the researcher to gain a deep understanding of the experiences and views of children in terms of their personal preferences. Through case study methods, a researcher is able to go beyond the quantitative statistical results and understand the behavioral conditions from the actor's perspective. By including both quantitative and qualitative data, a case study helps explain both the process and outcome of a phenomenon through complete observation, reconstruction, and analysis of the cases under investigation (Winston, 1997). The distinctive features of qualitative research are recording detail of behavior, using the non-structural, social, and cultural context of the subject, developing the description at the level of its deep meaning, and answering the questions about "what", "how", and "why". Qualitative research can be used to promote the development or implementation of policies used in schools, including the preschool level. This method can be used to identify an example or problem that is rarely perceived and even the type of intervention required.

Furthermore, it is possible to study specified criteria in order to help schools grow in education to identify and develop criteria for education and assessment (Treasury, 2012; Becker, Cummins et al. 2017; Hancock and Algozzine, 2017). In qualitative ways, the discovery of complex secrets and definitions is determined by connecting to participants' behavior and their way of interpreting their positions and their views (Strauss and Corbin, 1998; Woods, 2005).

In HCI, data can be gathered in a variety of ways, such as interviews, observations, focus groups, case studies, and so on, all of which are very important for achieving the goals of qualitative research (Hammersley, 2018). The qualitative research advantage can be described in such a way that this kind of research allows researchers to more deeply analyze the

participants' responses and experiences by relying more on their knowledge (Hancock and Algozzine, 2017).

Therefore, this thesis used a case study to understand the experiences of children, teachers, and parents at the preschool level of fostering creativity and learning in digital game-based learning. A case study inherently leads to a deeper understanding of the behavior of children, parents, and teachers. Data from this case study included responses to semi-structured interviews, observations, and recorded videos of children. The research has conducted face-to-face interviews with the children's parents and teachers. Teaching observations were performed using the technology in each participant in the week after the interview.

3.6 Description of the sample

In this research, a sample of apps preloaded is used into one tablet for seven children aged 3-6 years old in Foundation Stage 1 and 2 in a selected Montessori school. As previously mentioned, the apps used were the ones identified as the nine series of top effective preschool children's applications commonly used by 3-6-years-olds based on research by Marsh (Marsh, Plowman et al., 2015; Marsh, Plowman et al., 2018) in the United Kingdom. Nine series of effective training digital application games designed and introduced by reputable companies were also reviewed, evaluated, and selected (Marsh, Plowman et al., 2015; Marsh, Plowman et al., 2018).

These DGBL apps also have gotten rewards and having the most download in the Apple Store by 2020 (see table 3.5). These applications were installed on an iPad so that the teachers could share them with the children. The applications were sometimes chosen by kids, and sometimes kids were directed to specific programs by the teachers and researchers. Participants were first chosen via e-mails sent to teachers and parents at a Malaysian preschool. Teachers and parents responded by email, showing their interest in participating in the research, and afterwards the author of this thesis followed up in person to ensure that the teachers and parents

in question, along with their children, were willing to participate. Also, in this thesis were made sure that all participants were aware of the research conditions. Seven participants from children, seven parents, and 2 teachers from Montessori preschool were selected (see Appendices B & D).

The school where the participants were selected was in its second year of opening a new school, and for this reason, each participant was in the first or second year of teaching or studying in the school. All the teachers were female, except for special education teachers and support staff, so both participants were female teachers.

Although this thesis was not allowed at the school (the letter is available in Appendix E), another location was used for this research. This location was a specific playground for preschoolers suggested by the mother of the participant (6). Montessori preschoolers, parents, and children were also invited and given an encrypted name to protect their identity and keep it confidential.

3.6.1 Description of teachers and parents

3.6.1.1Teachers Participants

In this thesis, purposeful sampling has been used to identify teachers with experience in the research and preschool question (Creswell, 2021). Palinkis (2015) explained that targeted sampling is a method used for identifying and selecting information-rich materials (Palinkas, Horwitz et al., 2015). This includes selecting knowledgeable and experienced people, in which case education in digital game learning in particular.

Teachers need to have a teaching position at the preschool level with at least one year of teaching experience. Teachers have been recruited and interviewed through surveys. The sample size included two of the teachers who were interviewed. Based on the amount of time available, both the researcher and the participants were determined the time and extent of the

interviews. The teachers were selected from the same Montessori school where the child participants studied (see Appendix B).

Two teachers from Montessori school were selected in this research, described below (see table 3.2);

Teacher 1 – Teacher 1 taught for a year during a pre-school. She had previously taught preschool, being a member of the preschool team, and not the class captain. She said:

"I am very much in favor of digital technology and digital-based educational games, and although I'm not very good at using digital and DGBL technology as I should, I feel the need for more practice for teachers".

Teacher 2 - Teacher 2 had four years of primary school experience and taught this class during the interview. She was the captain of the preschool level team, technically describing herself as quite comfortable. She said:

"I'm not one to read the instructions for doing this."

She had no experience working in technology education courses during her college education since her bachelor's degree was in an unrelated field, and the only course she took was how to use a tablet to record the morning of children's attending as part of her teaching license.

The transcript of Teacher 1 and Teacher 2 was shown with the codes of "T1"and "T2" and their relation in every code.

Table 3.1: Demographic profiles of the case study teachers

Teachers	Years of Teaching Experience	Gender	Taught Previously
Teacher 1	One year	Female	• Foundation stage 1, 2 (Reception)
Teacher 2	Four years	Female	• Foundation stage 1, 2, 3 (Reception) • Key stage 1

3.6.1.2 Parents Participants

The descriptions of the parents of the seven children (preschool level) selected from Montessori School are also given below (see table 3.3);

Parent 1– Parent 1 was the mother of participant (1) (female, aged 6). She was 35-year-old and keen to explore her child's technology and digital games. She states:

"Although digital games can have a negative effect on children in terms of addiction because of their attractiveness, it seems that this attractiveness makes it possible for children to practice for learning more time".

She said:

"I believe these Digital games have a positive impact on young children. On the other hand, consumption can be managed through parents or teachers."

Parent 2- Parent 2 was the father of participant (2) (male, aged about 6) at the age of 40. He said he was not comfortable using technology at all. He states:

"I only use my laptop for basic necessities. I don't really know much about this technology."

Parent 3 - Parent 3 was the mother of participant (6) (female, aged about 4). She was 27 and owned a café shop with a playground full of toys for young children. Being really in favor of using technology and digital games amply for preschoolers, she said:

"I wanted to use the touch tablets and DGBL applications in my café shop and playground to keep the kids busy."

Parent 4 - Parents 4, 35, was participant (5)'s mother (male, aged 4 and a half). As a housewife, she was very fond of technology and mobile. She agreed to use this technology and evaluate her son in digital games. She said:

"The use of technology is essential for children because the future of children depends on acquiring skills in using this technology."

Parent 5 - Parent 5 was the mother of participant (3) (male, aged 5) and a doctoral student. She was positive about this project which was done with her son.

Parent 6 - Parent 6 was the mother of Participant (4) (aged 4 and 3 months). She was a 42-year-old woman with little about technology and digital games on tablets for the use of young children. Her use of technology was limited to the use of the smartphone in her hands. She stated:

"I use my smartphone only for applications designed for adults, but, interestingly, this technology can be used to foster creativity and other things for children."

Parent 7- Parent 7, the mother of participant (7) (female, aged 3 and 2 months), was a 30-year-old woman who, while agreeing to use traditional games and changing traditional

methods for children, agreed to use digital technology and games in children's daily lives. She said:

"Children must have sufficient skills and experience in the use of digital technologies and digital games, as new teaching methods have been mixed with these technologies."

Table 3.2: Demographic profiles of the case study parents

Parents of Participants	Participants	Gender	Age at start of the study
Parents 1	Participant 1	Female	35 years old
Parents 2	Participant 2	Male	40 years old
Parents 3	Participant 3	Female	36 years old
Parents 4	Participant 4	Female	42 years old
Parents 5	Participant 5	Female	36 years old
Parents 6	Participant 6	Female	27 years old
Parents 7	Participant 7	Female	30 years old

3.6.1.3 Description of Participation (children 3-6 years old)

All children in Foundation Stage classes 1 and 2 were invited to participate in the research. This thesis examined and evaluated the impact of digital education-based games among seven participating preschool children. The demographic profiles of the children are given in table 3.4 (see table 3.4).

Table 3.3: Demographic profiles of the case study children

No	Gender	Age at start of study	Class
Participant 1	Female	6 years	Key stage 1
Participant 2	Male	5 years 8 months	Key stage 1
Participant 3	Male	5 years	Foundation stage 3 (Reception)
Participant 4	Male	4 years 3 months	Foundation stage 3 (Reception)
Participant 5	Male	4 years 6months	Foundation stage 2 (Reception)
Participant 6	Female	3 years 8 months	Foundation stage 2 (Reception)
Participant 7	Female	3 years 2 months	Foundation stage 1 (Nursery)

The participants recruited in this research project affiliated with Montessori preschool. Montessori education for preschoolers is fundamentally a method of learning through playing games. Montessori preschool in Malaysia did not allow to do this research at the school (the letter is available in Appendix E), so a different location was used to conduct this research (see Appendix E). This research was conducted at the suggestion of the mother of one of the children in a very similar environment to the Montessori school environment and special for children. All teachers and parents participated in this project with their full consent and voluntarily (given the knowledge of any consequences of this research) (see Appendices B & D).

This place was a playground for the kids suggested by the mother of participant 6. Montessori preschool teachers were also invited there. In this research, data were collected from observations and interviews with two teachers and seven parents of these children. In total, the duration of observations, interviews, video recordings, and the first and second experiments was about three months. The video was recorded in two steps. Each step of the interviews and filming in the first and second experiments lasted ten days separately.

The assessment courses were too short to assess student performance and learning, requiring longer evaluation and long-term experience. However, because of the nature of the daily work schedule in this study, there was a time limit for both the teachers and parents as to interviews and observations. As respects due to the time that teachers and parents could participate in this project, the planned time for two experiments, one and two, was during two separate 10 days in three months. Therefore, this study was also planned according to the time constraints of the participants. In the present study, teachers and parents were given a 45-minute preparation period. Interviews took place during these periods without interrupting teachers' or children's school planning or lunch. Teachers' observations were made during the day after school time, approximately from 4-6 p.m. Each training course took approximately 20 minutes in length during the observation course, described in detail in this chapter.

Although not all children had access to the tablet at home, this thesis tried to ensure that all children had the experience of using the tablet before conducting interviews and filming. The choice of applications was sometimes made by children. Sometimes children were directed by teachers and researchers to play with applications. This thesis recorded the child's interaction with the screen through his phone camera. A total of 21 hours of videos of children's behavior were recorded.

3.7 Ethical protection of participants

In this thesis, consent was received from parents, teachers, and children (see Appendices B & D). All the stages of these interviews and research were conducted with full parental permission (Dockett and Perry, 2011). In addition to the body language and other gestures indicating the children's discomfort, attention was paid. For example, according to a teacher or researcher, once the children had a feeling of discomfort or fatigue, interviews and video recordings stopped.

3.8 Selection of applications

Nine series of effective training digital application games, designed and introduced by reputable companies, were also reviewed, evaluated, and selected by Marsh (Marsh, Plowman et al., 2018). The games also rewarded and had the most download in the Apple Store by 2020. These applications were installed on an iPad so that the teachers could share them with the children. This section explained and answered the question of "Why nine series of applications have been used in this thesis?"

Marsh (2015; 2018) explained in his research that he had conducted an online evaluation of apps and the choice of digital educational games for parents and children. Marsh pointed out the management of digital games and their selection and finding by parents has been used in a wide range of strategies that relate to parents and families of young children (Marsh, Plowman et al., 2015; Marsh, Plowman et al., 2018). Among these strategies are:

1) Using search engines in the app store or games using general search terms such as "learning numbers for kids", "free educational games for three-year-olds".

2) Looking for reputable and popular broadcast and television apps.

3) Looking for games that were related to the interests of the child, e.g. Dinosaurs and Prince of Little Duchess.

4) Looking for games that the child already knows and loves.

5) Downloading Applications in series.

6) Downloading games from reputable developers who make good products.

7) Bringing new unknown apps related to well-known games in the game market at the game store.

8) Describing the introduction of apps, for example, the degree of interactivity of the game, its images, and the stars.

9) Watching games on television advertising.

10) Reading and following the parenting recommendations on the weblogs by Marsh and colleagues.

11) Considering the age and condition of the children in the description of the game by Parents.

12) And finally, download the game if it is appealing to the children's friends on the recommendation of the child (Marsh, Plowman et al., 2015; Marsh, Plowman et al., 2018).

In summary, the features of the digital games that parents have been looking for were as follows: interactive and educational fun and free digital games are usually used; even some parents have suggested that they would be willing to pay if the quality of applications was higher (Marsh, Plowman et al., 2015; Marsh, Plowman et al., 2018).

This thesis investigated the intervention of DGBL principles in the level of learning in young children during fostering creativity. Although Marsh (2015; 2018) examined all kinds of apps in young children that included the categorization of entertainment and education, this thesis selected only educational apps for the preschool level (3-6 years old) (see table 3.5).

The video recordings were used on two phases of ten separate days over a period of 3 months. In the first phase, in Chapter 4, nine series of educational games were selected (see table 3.5). After installing the selected apps on the iPad, it became available to teachers so they could share apps with children. The equipment required for this research was placed at the research site. The choice of the applications was sometimes made by children and sometimes the children were guided by teachers to play with the application. Although children's play and attention to each of the selected digital games was quite relative, the researcher also prepared a schedule for equal time of use of digital games and provided it to the teachers. Therefore, each child was tested to each digital game and observed by the researcher. Therefore, the researcher ensured that each child paid attention and played an equal time for each game in a specific schedule. In this thesis recorded the child's interaction with the screen through the phone camera is recorded. A total of 21 hours of video recording of children's behavior were produced.

Table 3.4: Selection of digital game-based learning applications

No	Name of digital game-based learning applications	Training focuses
Game 1	AR flashcard – alphabet & more	English language skills ,& Science (learn the names of animals)
Game 2	Meet the animals	Science (learn about animal and their habits), music
Game 3	Toca Boca Nature	Science (learn about enviroment)
Game 4	Toca Boca Doctor	Science and knowledge (medical and human body)
Game 5	CBeebies story time	Science, Knowledge, Roll playimg, music
Game 6	Squiggle	English language skills ,reading & writing
Game 7	CBeebies play time	Science, Math, Constructing & creative activities
Game 8	Minecraft	Scienese,Technology, Mathemathics, Engeenering (STEM)
Game 9	Peppa pig collection (paint box)	Memmory, Matching, Sorting, Constructing & creative activities

3.9 Simple prototype of STEM

In the second phase, in Chapter 5, a simple prototype of STEM apps based in DGBL is designed, onto one tablet for seven children aged 3-6 in Foundation Stage 1 and 2 in a selected Montessori school. The simple prototype of STEM was designed in the "Hopscotch" app (see figure 3.7, 3.8, 3.9).

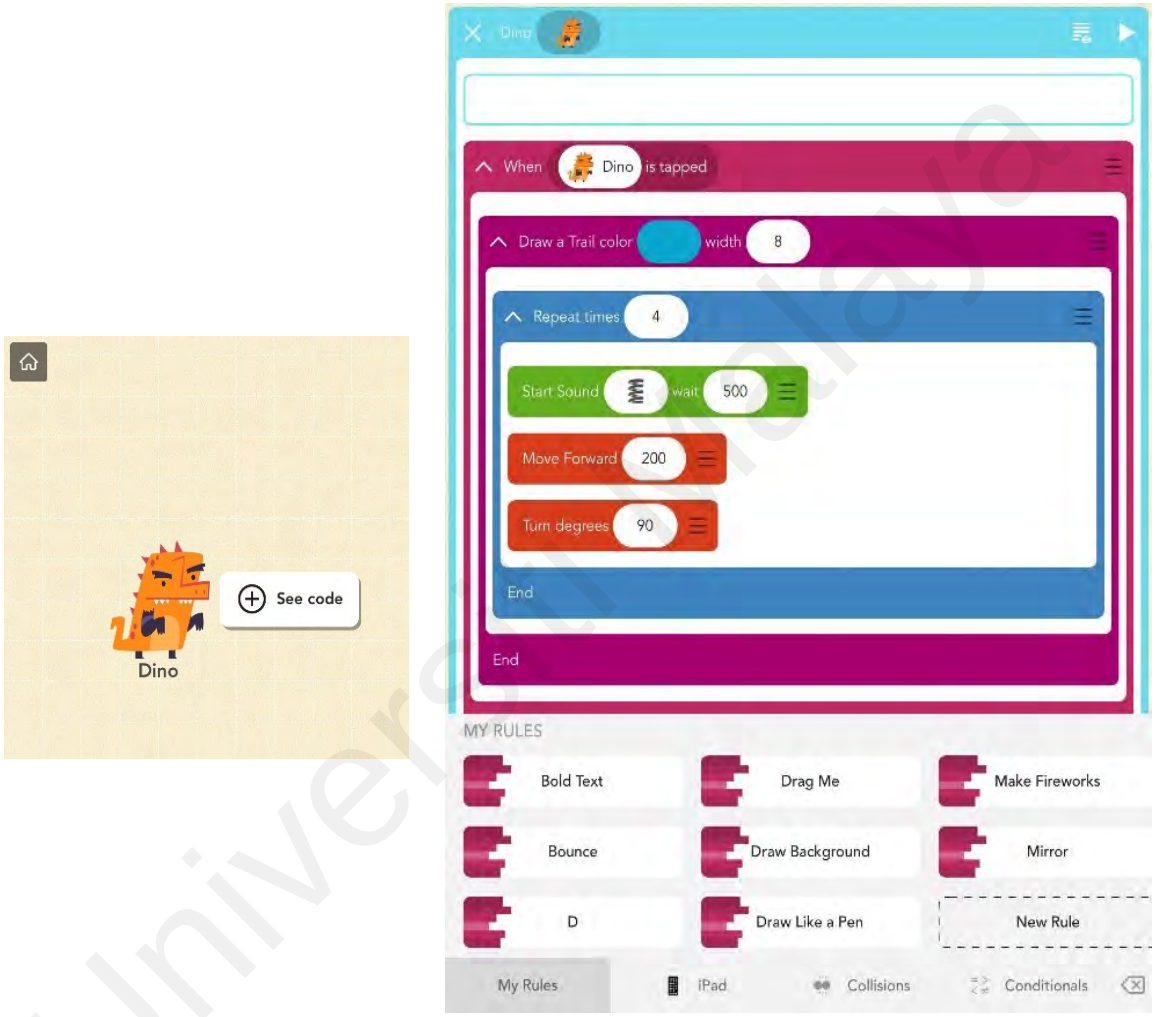

Figure 3.7: **Sample of characters and codes in simple prototype of STEM**

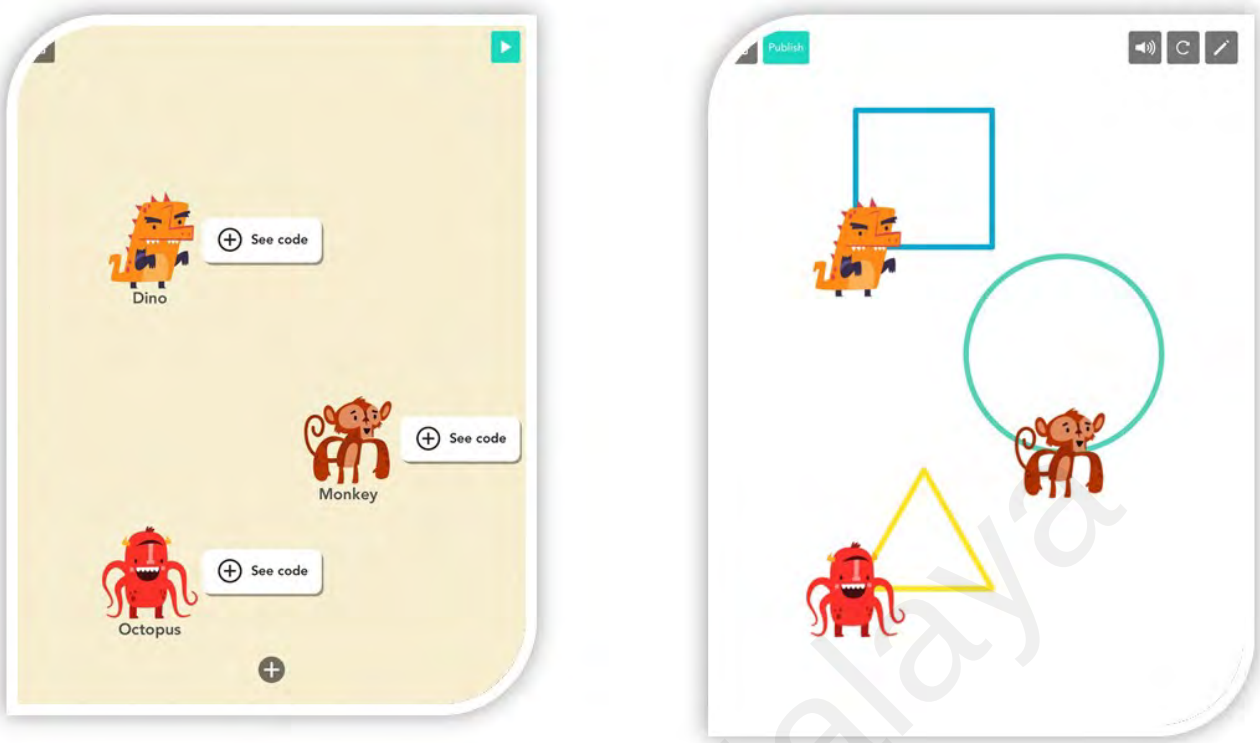

Figure 3.8: Sample of characters in simple prototype of STEM

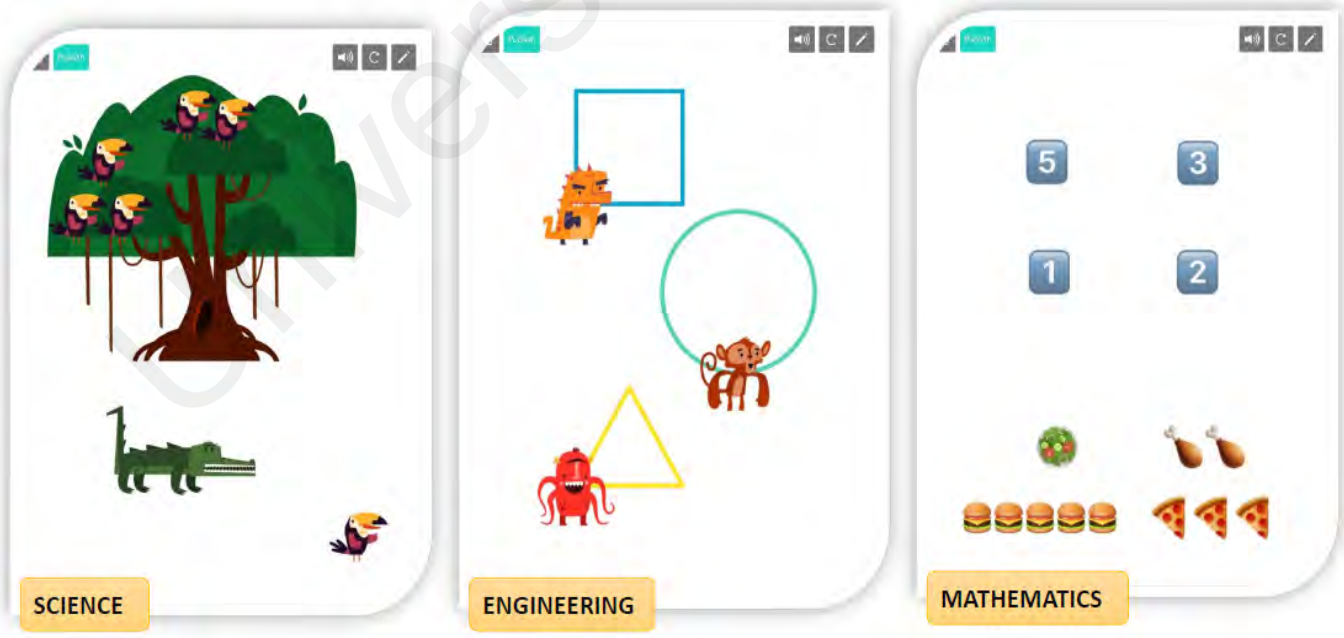

Figure 3.9: A shot of Application

3.10 Instrument to use apps

In this research, an iPad touch screen tablet is used. The use of computers and laptops restricts the creation of educational activities for preschool children. For example, to use a computer or laptop, the child must be in a fixed place, which in turn causes the child to feel tired and restless. On the other hand, computers and laptops need a device such as a mouse and a keyboard to interact with the user. This feature, especially for young children (3 to 6 years old) that their motor skills are not well developed, caused problems, fatigue, and made them feel unhappy about their inefficiency (Nacher, Garcia-Sanjuan et al., 2016). Therefore, the evaluation of this type of research does not seem to be highly accurate. Hence, the researcher's use of the touch tablet enhanced the ability to record carefully children's reactions when using applications. The touch screen tablet form factor and size offers more opportunities for supporting collaboration between peers among young children. Thus, these devices allow the movement of children with the tablet where the activity is being carried out.

3.11 Data-Collection Procedures

As mentioned previously, in this research, two experiments were performed in the fourth chapter of the first experiment, and in the fifth chapter of the second experiment. The method used in these experiments is through qualitative data analysis, including data collection, data separation, and data retrieval in a way that is relevant and meaningful to the study (Harding, 2018). For this case study, interviews and observations were analyzed to identify common themes and trends. The data analysis methods used focus on the results of interviews and observations, as well as the collection of documents as to the improvement of learning and creativity among children.

3.12 Interviews

The interview is the most common form of data collection in qualitative research. According to Oakley (1998), a qualitative interview is a kind of framework in which standards and practices are not only recorded but also achieved, challenged, and strengthened (Oakley, 1998). Interviewing and observing participants' behavior is a powerful way to explore and analyze complex behavioral phenomena (Rogers, 2012). This interview method is a useful experience for analyzing user behavior. The interview method allows the researcher to understand a particular aspect of the study by understanding and analyzing each of his commentators to examine the main concepts that are meaningful to them in a special form. On the other hand, this interview method enables researchers to provide empirical knowledge that goes beyond what is already known, particularly about aspects not taken into consideration in the research on individual behaviors and attitudes.

Specifically, this method enables the researcher to understand the concepts and observations of observed phenomena based on descriptions spelled out by the person involved in specific events or situations with particulars (Costa, 2009). Researchers can control the data from the interview. In effect, through interviewing and viewing the interviewer, they can also interview topics that deal with viewing behavior or answering questions to communicate with the user. For example, based on the questions and answers of participants, the researcher can define more concepts by expanding the finer details. In addition, researchers have the ability to discover sustainable concepts that may be similar or contrary to existing knowledge. In other words, the interview method does not limit researchers to existing theories or concepts but allows them to add information that would completely invalidate the theory (Rogers, 2012). Through interviewing, a different perspective or understanding of a particular aspect of the participants is presented, and many of the individual experiences of the participants may remain unknown. For this reason, interviews are usually particularly valuable since they are

analytical though time-consuming (Rogers, 2012). There are several techniques for conducting studies and interviews, such as handwritten or typed questions, photo, audio, or voice mail and video. The interviews can be done with a pen and paper, electronic sheets, audio recorders, video recorders, mobile phones, etc. Therefore, in general, each of these interview modes or their totality could be arranged by specific goals by the researchers, which can be analyzed from a variety of perspectives (Palen and Salzman, 2002).

3.12.1 The semi-structured interviews and questionnaires

This research used two main methods for data collection: semi-structured survey and semi-structured interviews. The table questionnaire in appendices A & F contains several open-ended questions that produce qualitative data and several closed-ended questions (by selecting the suggested answer). Both types of questions are guided and supervised by teachers and professors specializing in preschool level and were also derived from the Marsh research (Marsh, Plowman et al., 2015; Marsh, Plowman et al., 2018)(see Appendices A & F).

The open-source refers to (Marsh, Plowman et al., 2018) for "Experiment one", and (Fredericks and Kravette, 2014) for "Experiment two", which allows this thesis to investigate the children's behavior. On the other hand, researchers and interviewers (teachers) have more freedom to record their opinions. Qualitative interviews that focus on open words and questions are more appropriate for research because these types of interviews and questionnaires lead to more specific features and dimensions of realization (Cohen and Crabtree, 2008). Therefore, these types of interviews are a kind of challenge that should be interpreted and deeply understood through answering the questions of this type of interviewing, and this depends entirely on the researcher's perception and extent of his experience in the research.

As mentioned earlier, semi-structured interviews were conducted to understand the experiences of children, teachers, and parents about the use of digital game-based learning applications. A list of questions has been created to help facilitate discussion of key concepts in the context of ACCT, Hughes' classification, and the principles of learning and creative teaching in "Experiment one" in Chapter 4. Then in Chapter 5, there was a list of questions to help facilitate the discussion of the main concepts of the proposed conceptual model on STEM-based learning simple prototype. Participants were able to express their ideas; all children's movements were recorded, and the thoughts and concerns of mothers and teachers were recorded during interview sessions. This thesis used a list of questions to guide the interview questions (see Appendix A). When the answers were received, also improvised follow-up questions about the discussion were asked (Saldaña, 2021). In some cases, the questions were open, and in some others, cases contained planned programs based on the answers. The conversations are recorded through the software and transcribed for coding after the interviews. The recording took place only with the consent of the interviewees. After making the initial summaries, the encryption process for data analysis began. Codes are labels that assign symbolic meaning to descriptive or inferential information collected during the study. These are short phrases or words that symbolically assign a feature to the data. This process can be as small as a single word or as short as a paragraph. Codes are primarily used to retrieve and enable similar data pieces to quickly find and collect information about a specific question or topic (Saldaña, 2021). First, the list was created and the scripts for each code were analyzed, and Nvivo software was used to organize it. As previously explained, the codes were analyzed for patterns and trends related to research topics and questions for the final analysis, which was created as a narrative.

3.13 Video recording

One of the most useful ways of understanding the participants' behavior in the research is through the video study method (Rogers, 2012). In this mode, the participants' activity is focused on a particular subject. This method is very useful for scholars to help researchers understand the participants' behavior and activities (which cannot be directly observed). In addition, this method allows researchers to find more accurate information about the logic of participants' behaviors to resolve some problems.

Video recording is principally divided into structured and unstructured. By asking questions categorized in a table designed by the researcher, participants answered these questions through their companions (Rogers, 2012). On the other hand, there are sometimes no questions in this method, and only recording any incident through a digital camera for participants is provided. Therefore, this opportunity is created for the researchers to process all the special monitors (Palen and Salzman, 2002). In this way, selected teachers had a camcorder for filing events at the research site, for example at school for a specified period of one month or more. During this period, observers prepare one session per day for recording videos. This process is for providing necessary information for the researcher. This information includes emotions, behavioral dimensions, reflections, and other issues in the environment. Previous research shows that this approach has not only worked to complete existing qualitative approaches but also to develop an understanding of the dimensions and other aspects of research (Buchwald, Schantz-Laursen et al., 2009). Using these interviews and written researches to achieve studying widespread behavioral dimensions and a deep understanding of the feelings of the participants is useful. As mentioned earlier, video recording of participants provides extensive information to the researcher, including emotions, behavior, daily activities, and so on. This method is much more workable and useful than the other methods of interviewing as previously mentioned.

As previously stated, in this research, the children's actions were entirely recorded by a mobile phone camera, which focused on the child's interaction with the screen. Teachers needed to fill in the forms provided by the researcher after observing the preschoolers' activities (see Appendices A & F). The interviews were conducted during two separate weeks with each of the 7 participants and 2 teachers as well as 7 parents of the participants. The researcher collected 20 minutes per experiment (1 & 2) of interview data from each participant in the scheduled sessions. Interviews took place in a place similar to the Montessori school for young children in Malaysia, where all interviews were conducted to ensure privacy in a quiet place. Prior to the interview, teachers and parents signed a consent form (Appendices B & D). Each interview took place at a time when the teachers were present there. The questionnaires were prepared based on the afore-mentioned frameworks, with examples presented in each section focusing on observing teachers from participants (7 young children). The interviews having been conducted were singly transcribed by the researcher using Rev.com. The text was sent to the relevant partners (parents and teachers) and verified. The data obtained from the interview was then encoded using Nvivo software.

The video recording took place in the second phase of ten days over a period of 1 month. In the whole of the interview, the researcher recorded and answered the interview questions by observing children from engaging questions that promote STEM explorations based on collections of STEM curriculum (Fredericks and Kravette, 2014) (see Appendix F). Teachers conduct the experiment with each and every child in a quiet location. Teachers introduced the app to children and then children are recorded using the prototype. The materials and equipment are set up in rooms near to classrooms. The children are recorded using an app sometimes chosen by themselves and sometimes by teachers. The video recorder was focused on the child's interaction with the screen. The researcher needs to record videos for a total of 21 hours in this phase.

Observations were used to assess perceptions, reactions, and educational strategies for young children, teachers, and parents. These observations were recorded with the teachers' permission. The concepts and themes of the checklist are prepared from the codes created in the initial teacher interviews (Harding, 2018). History and time were coordinated with teachers and parents. Each observational data was entered into the encryption process that began in the first interview and was included in the final narrative (Dustman, Kohan et al., 2014).

3.14 Data-Analysis Strategies

There are several methods for analyzing data in qualitative studies. The data required for qualitative research includes interviews, observations, films, etc. One of these resources, or a combination of several sources of data collection, can be helpful in data analysis. In a study, Strauss and Corbin (1998) showed that these interviews could be conceptualized. All of the transcripts were analyzed using the basic theoretical approach proposed by Strauss and Corbin (Strauss and Corbin, 1998). Then, Hatch (2002) introduced an inductive analysis model that principal data be gathered by qualitative researchers directly through field notes from observations, transcripts of interviews, and data from artifacts from research sites or social phenomena (Hatch, 2002). This allows the researchers to make sense of the social aspects and essentially quantify the information into data to have proceeded for trends and understanding. The data analysis stage is required to be followed by data collection for a deeper understanding of the participants' behavior. Most of these approaches involve textual analyzes, both in terms of verbal and written behavioral records.

The main challenge for researchers in qualitative studies is the high volume of qualitative data that makes it possible to follow a specific method of qualitative analysis (Strauss and Corbin, 1998). Such a method helps readers and researchers investigate or combine and or compare the study with other studies carried out within the same research area (Strauss and Corbin, 1998). Grounded theory is an approach typically used with qualitative studies to

identify, extract, analyze, and report patterns (themes) of text-based data. In this research, the data obtained from the interview and observation were analyzed using grounded theory (Hatch, 2002).

After collecting the interview data, the researcher began the transcription of the information, verifying the validity and coding process (Hatch, 2002). Following the interviews, observations and data were collected and confirmed. This thesis used inductive analysis to analyze the data in the interviews (see figure 3.10).

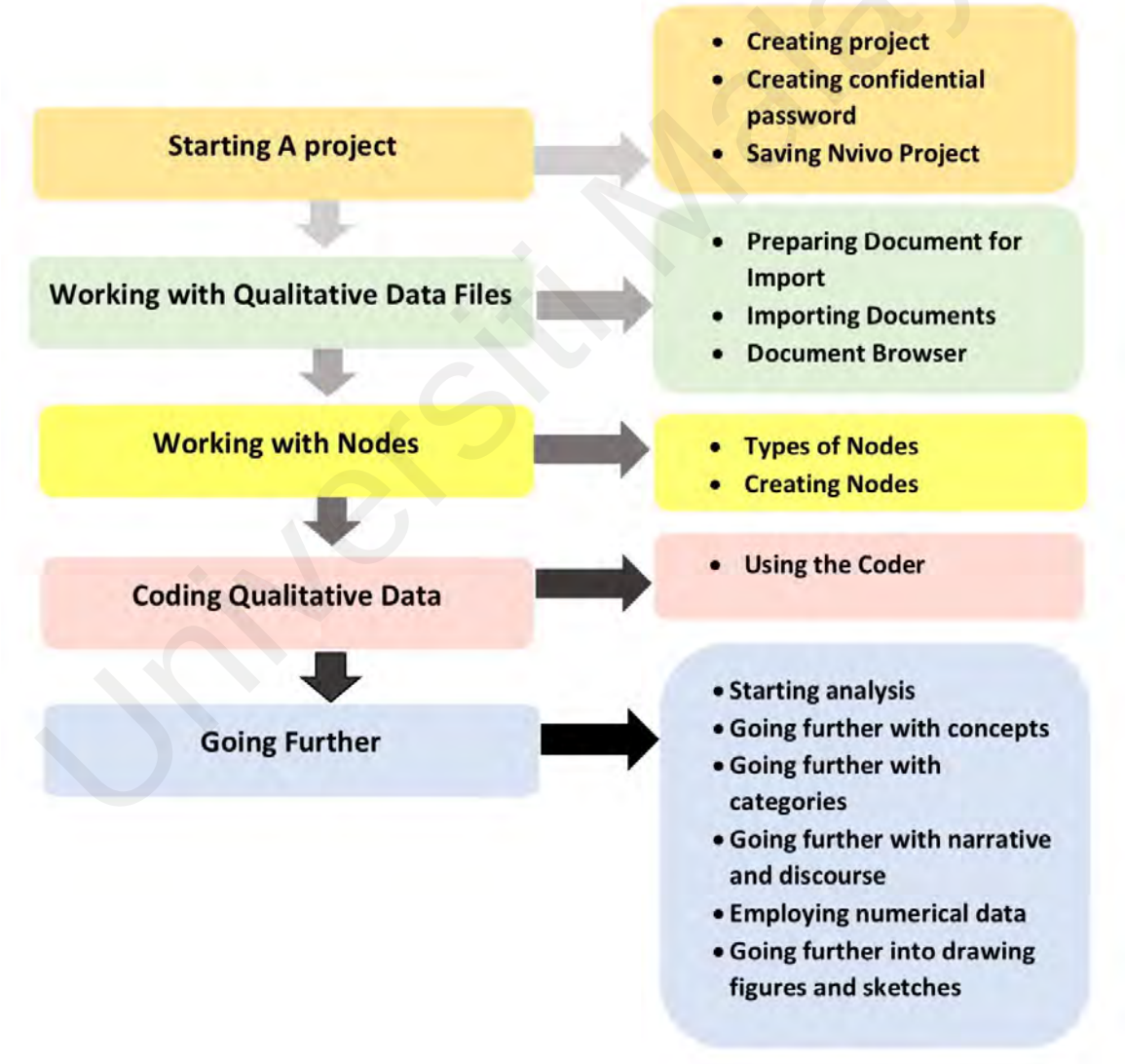

Figure 3.10: Generate categories/ themes based on the codes

To convert (information or data) into a code, this thesis began with more specific information toward general ideas (Hatch, 2002). In this thesis, the initial process of converting information or data into a code as described by Saldaña (2016) is used and broken down into three different cycles (Saldaña, 2021). Based on the semantic analysis using Nvivo, data is coded for the types of Play and Creativity; Game difficulty; Pedagogy; STEM learning (see figure 3.11).

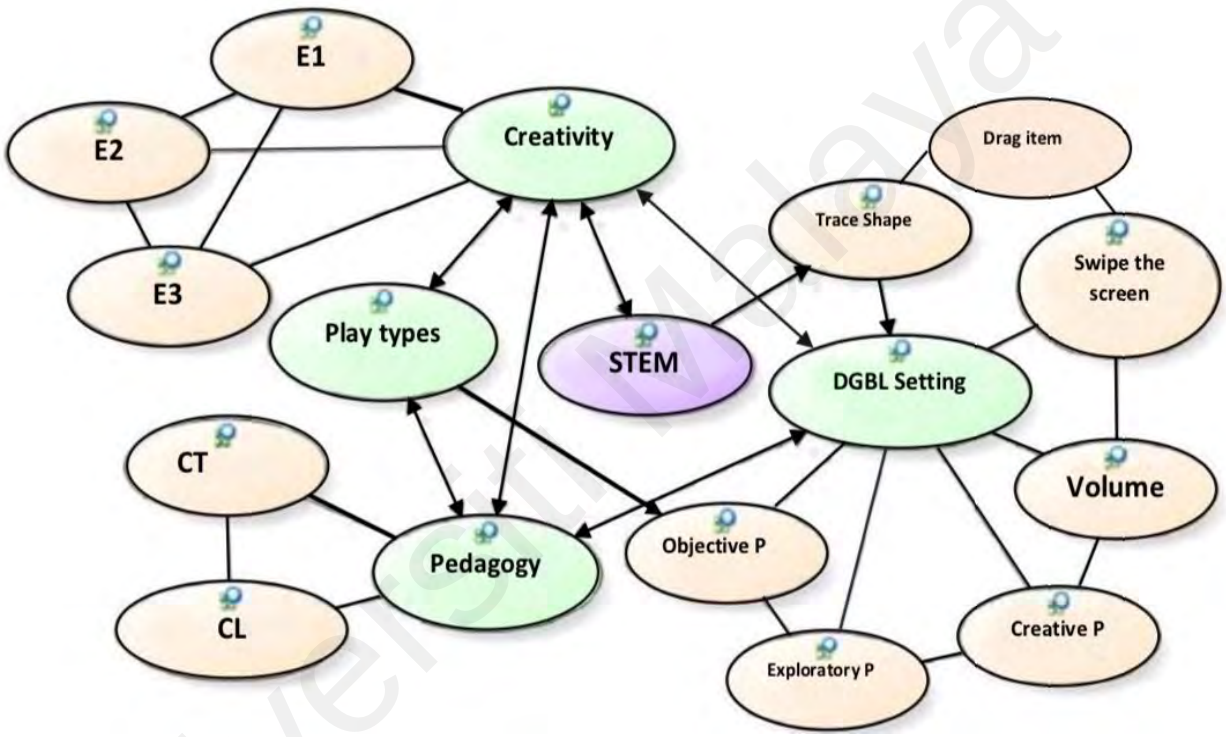

Figure 3.11: Visual mapping based on the semantic analysis using Nvivo

To deeply understand the information, each version was reviewed and read several times. This was followed by data collection. After completing the interviews and analyzing the data, the research was shifted to data observation and analysis. Over a two-week period, seven children together with their teachers and parents (who participated in the interviews) were shown videos. After reviewing the validity of the data, the results of the observations were analyzed. Having ensured that not all sections of the checklist helped her answer research questions, the researcher focused on specific aspects of the recorded film to add to the list of codes generated during the interview.

Interviews were analyzed using three planned goals to identify concepts, categories, and behaviors as well as their relevancy. This analysis process allows the present thesis to search and develop a central theory based on all dimensions and data. Data were coded deductively for play types and creativity and creative thinking types. In addition, inductive coding was used to identify themes emerging from the research questions based on inter coder reliability (see figure 3.12).

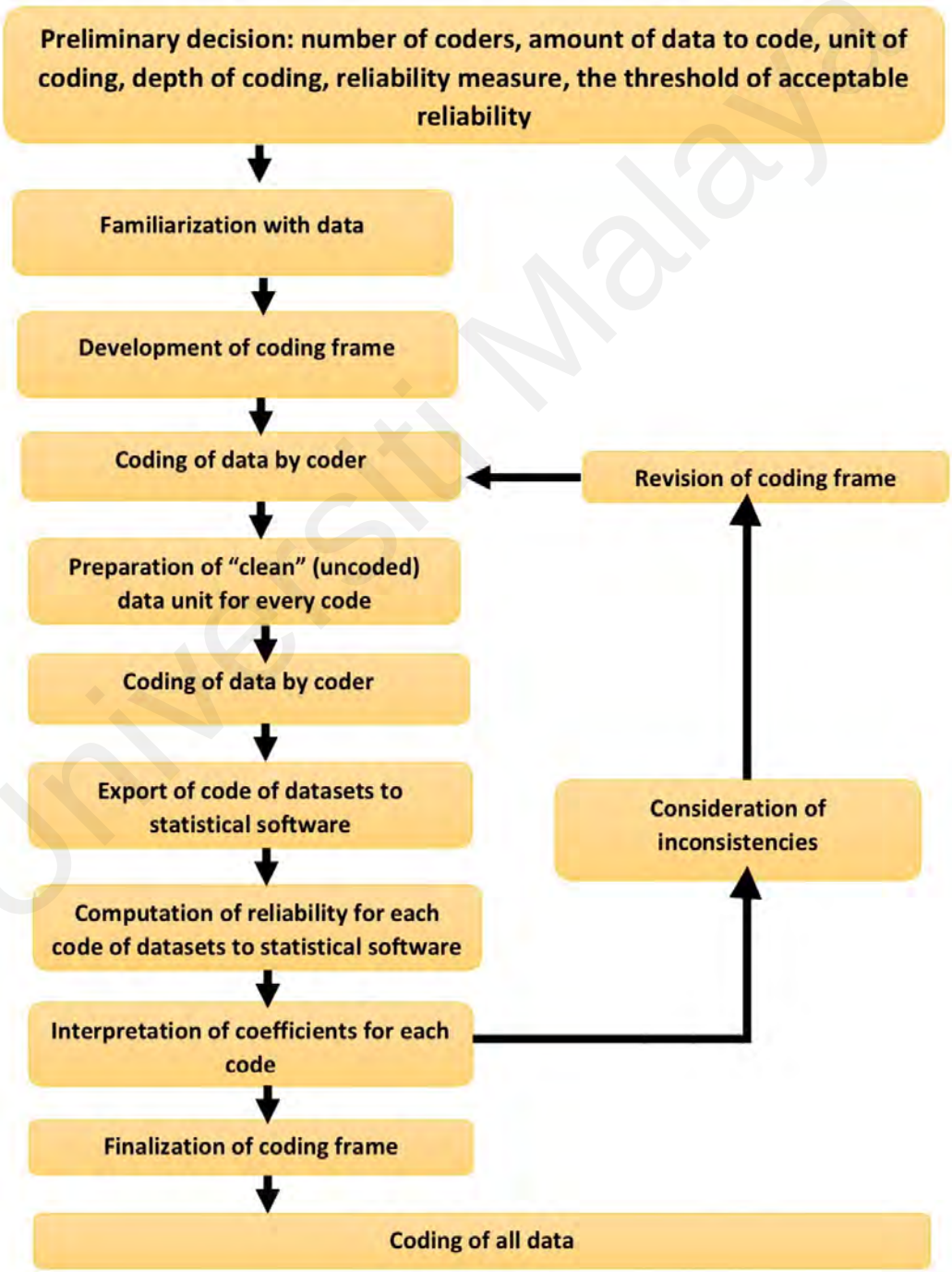

Figure 3.12: The flow of an inter-coder reliability

Video recording data helped this thesis know more about how to use tablet technology in digital game-based learning in young children. In particular, this thesis focuses on the six main types of checklists that help to answer research questions. These six sections include young children (preschoolers), the role of teachers and parents, creative activity and divergent and critical thinking, learning activities, play, and use of tablet technology in children. Then the researcher managed to review the set of codes created as well as identify patterns between the information. Also, the basic concepts and applications of this technology were identified and added to existing codes. The final review of the information from the observations was done and the data were added to the existing codes and new codes were created if necessary in Nvivo software.

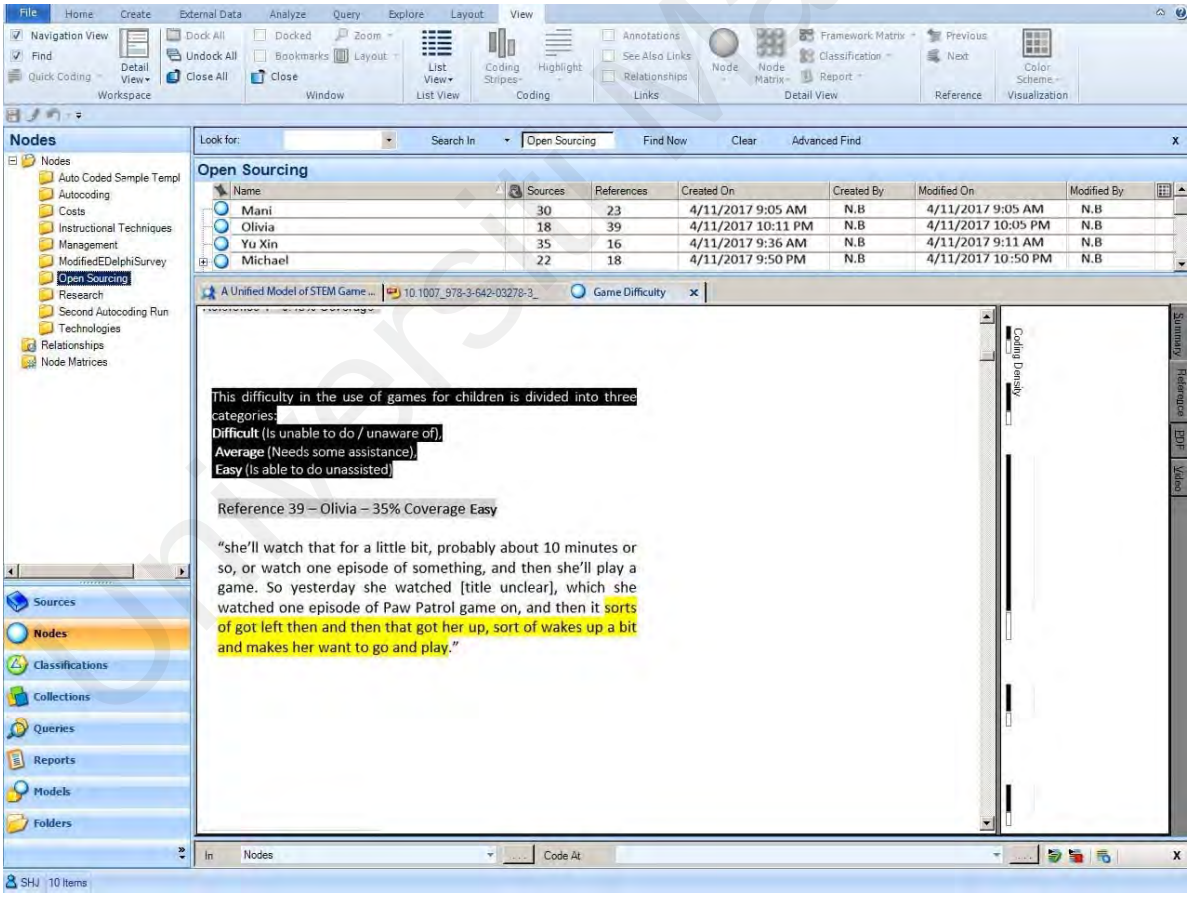

Figure 3.13: Pattern coding using Nvivo (an actual analytical snapshot).

As previously mentioned, Nvivo software was used to collect the data. This software enabled the creation of codes, discovery of key ideas, concepts, and themes during interviews,

observations, and data collection. The example in figure 3.13 shows pattern coding using Nvivo (Saldaña, 2021). Nvivo software was used to collect the data since this software made it possible to create codes to discover the main idea and concept during interviews, observations, and data collection (see figure 3.13).

Table 3.5: Example of how transcriptions were coded.

Phase 3 (Dimensions of the study design)		**Phase 2 (Creating categories)**	**Phase 1 (Nvivo coding)**	**Example of quote**
Exploration	Exploring	Tending to discover the potential of a challenge, activity, or substance	**E1**	The child tried to play the game buttons on the tablet so that she could understand the rhythm of the game. She showed that she enjoyed it and went on discovering the next step. The shapes and attractiveness of the game stimulated her and gave her more to continue playing.
	Engaging in the new activity	Ready to get involved in an activity and coming up with an idea	**E2**	The child watches other children play with the app where painting and coloring are used. He approaches those children and tries to pick a color with his finger. Drawing his hand on the tablet screen it will turn yellow to spread.
	knowing what you want to do	Enjoyment of being curious when choosing a game	**E3**	When a child is playing a game of building an app designed for the tablet, he points his finger at the next piece which he wants to choose as the next piece to make.

New topics were also recorded and coded during each question asked by the interviewees. Ideas and statements collected from interviews and observations were eventually created into 128 codes using an encryption process (Saldaña, 2021). Ideas and concepts may not have been

received correctly on the first reading. Hence, the data were repeatedly analyzed to lead to a new understanding and the discovery of appropriate codes. After collecting the themes and concepts, the number of codes was reduced to 30 codes using the model coding. With each question from the interviewees, ideas, and themes were discovered. The ideas and statements collected from the interviews and observations were eventually created into 128 codes using an encryption process (Saldaña, 2021) (See table 3.6).

This research used three types of coding procedures during data analysis to analyze interview documents: Open Coding, Axial Coding, and Selective Coding.

3.14.1 Open Coding

The first method for analyzing interviews is open coding, which allowed this thesis to examine, analyze, and compare the classification and analysis of information in separate sections. At this stage, organizing data with a constant comparison approach is intended to identify the themes and patterns within the data set. This kind of coding is to facilitate understanding of the doubts and differences between the codes in order to reduce the amount of information received from the interviews. Meanwhile, during open coding, the researcher identified issues for linking to the conceptual frameworks used in the research (Saldaña, 2021). While the themes and categories became brighter, the likelihood of the subjects being accepted through the full evaluation of the data was also increased and examined. The reliability of the data is in the usefulness and manner of answering the research questions in the interviews.

3.14.2 Axial Coding

The next approach is numerical coding to respond to preschool child interviews The categories were developed and were examined how the conditions, frameworks, and interactions of the classifications could be the answer to the questions and hypotheses of this research. At this stage, more comprehensive knowledge of the relationship between categories, subcategories, themes, and patterns was revealed. The documentation of the topics created by

the categories and diagrams represents the relationships between the various subjects. Each of the themes reinforced the classification by encoding word or words. Data was reported via a word processor and pieces attached to specific topics were drawn.

3.14.3 Selective Coding

In the final process, selection coding has been used. At this stage, systematically the main categories were organized and were produced from the responses of the interviews, the categories related to them, the confirmation of their relationships, and the presentation of the explanation for the non-developed groups. In this research, all aspects of programming have been investigated for defining and generalizing the codes. The purpose of this method of coding was to allow the researcher to get a deeper understanding of the experiences and interactions of the phenomenon desired. Each code was linked to a particular aspect of creative strengths, play, and enhancing learning. In total, 20 of the videos were coded by the researcher. Finally, the apps themselves were analyzed in conjunction with the outcomes of the video data analysis to identify features of the apps that either fostered or inhibited play and creativity and then enhancing learning. In this thesis, data from all stages of the study are shared to identify the play and creativity and then to enhance learning STEM demonstrated when children used tablets and apps. In this research, data were coded deductively for play types and creativity and creative thinking types. Besides, inductive coding was used to identify themes emerging from the research questions.

3.15 Identification of Attributes

Features that define and guide this case study include Human-computer interaction, creativity, creative and critical thinking, digital game-based learning, professional development, technology integration, teaching experiences, pedagogical techniques, 21st-century inhibitions, perceptions of preschool teachers and preschool students. Each young student's experience was based on prior knowledge, training, understanding, and attitude

toward digital game-based learning and the use of touchscreen tablets. The purpose of this process was to understand what is needed for the professional development of preschool students and to strengthen learning and creativity in digital game-based learning programs.

The study was based on the experiences of preschool students and their teachers in Malaysia. Participating teachers and parents shared their understanding of digital game-based learning experiences. Teachers discussed how to integrate technology into their teaching techniques. Each teacher had experience in teaching with a history of integrating technology into their classrooms. Each of the attributes discussed has helped in the overall understanding of young children and the teacher's experience in learning based on digital game applications (Thiele, Mai et al., 2014).

3.16 Member Checking

During this project reviewed members' checks with the participating teacher and parents for two weeks. After the interview and the observation section, the members were examined with each of the participants and confirmed that all the information was correct and valid. One week after the interview, copies of the observation were sent to each participant. After reviewing the collection of observations, interviews, and data, parents and teachers approved the list. This checklist was emailed to teachers and parents one week after data collection and was re-checked.

3.17 Verification

Reliability and validity are indications of whether the researcher’s information has value. The verification of the research and its outcomes are among the important factors for providing evidence of the quality of research. Despite the fact that research techniques are very diverse, there are no universally accepted criteria for assessing credit in qualitative research. In this

regard, even some researchers, owing to the lack of valid evaluation in qualitative research, question this researches, too (Ito, Gimenez et al., 2019).

Objective experience and satisfaction in surveys and qualitative studies can guarantee the credibility of those products such as applications and related research (Hammarberg, Kirkman et al., 2016). There are also differences in research based on the focus of research on the field of maturity and existing literature. Therefore, it can be said that quantitative studies are not better than qualitative studies, and vice versa. Credit in quantitative research is well-known and widespread, though (Brannen, 2017).

Indeed, in qualitative studies, epistemology-based research is derived from conceptual studies on basis of empirical studies that are fundamentally based on techniques borrowed from the natural sciences (Thompson, 2012). These studies refer to the development and stability of a particular paradigm as well as to the content which allows researchers to focus on the quality of their work. It may be argued that the reliability of these studies is determined by evaluating these results over time (Golafshani, 2003). Historically, qualitative research has determined content validity using the correlation coefficient (Hull, 1928). By obtaining a more comprehensive definition of Kirk and Miller (1986) the credibility of the outcome of the research is to conclude it through analysis and validity as the integrity of research. Hence, in the same way, as in other research on a specific phenomenon of the same amount of effort and a path, similar results have been achieved over time (Kirk, Miller et al., 1986).

However, to critically examine the findings of the qualitative studies, there is a disagreement over a general framework. Accordingly, the evaluation process varies completely from various studies. In general, the target sampling is for specific participants who are suitable for the research are examined. Probability sampling often carried out with quantitative research, is based on random sampling to ensure that all units have a probability equal to the selection (Davidson, 2006). Another sampling method is simple sampling refers to people being sampled

because they are the source of relevant information for researchers (Battaglia, 2008). Each study has unique goals and can be used in a variety of ways (Lietz and Zayas, 2010).

Although by examining the literature, it can be concluded that many researchers have used the term "credibility" to determine qualitative research (Cohen and Crabtree, 2008), the researchers state that the term used to refer to reliability, validity, confidence, and defense is used. Put differently, research can be reliable if it has collected the conditions necessary to ensure the participants' ethical views in a confidential manner and to analyze the findings provided with the necessary criteria (Lietz and Zayas, 2010).

Researchers believed that the merit of the qualitative method is that they offer deeper and more rigorous explanations (Finlay, 2006). Some researchers suggested it is sufficient to ensure that the interpretations derived from the data are as comprehensive as possible to replace a wide range of related fields and that a developed theory is widely differentiated in it has been done in terms of the subject matter of the research (Thompson, 2012). Lewis and Richie (2003) proposed two levels to ensure that reliable quality research is carried out; first, it is necessary to ensure that the research is strong enough; for this, it is necessary that internal checks are performed on the quality of the data and its interpretation. Secondly, it is necessary to provide confidence to the reader by providing information on the research process (Lewis, Ritchie et al., 2003). It is therefore essential to ensure that the quality of the exams and interpretations resulting from the findings are reviewed and analyzed several times during the study (Brannen, 2017).

The validity of the "accuracy" of a qualitative statement refers to the authenticity of a description, conclusion, explanation, interpretation, or other accounts. It can also be said that what is to be measured is the accuracy of the measurement together with the true understanding of the researcher. To ensure that the findings are accurate and transparent, it is important to ensure that substantive content and concepts are clearly supported by evidence. The sources of

evidence can be obtained through studies done previously and compared the quotes based on current interviews with the participants. This validated evidence is most important since it can be used by researchers to evaluate them in the future (Hammarberg, Kirkman et al., 2016).

3.18 Limitations

Previous studies have shown that the use of video recording techniques from participants' activities has prominent strengths, indicating that this method is very useful (Marsh, Plowman et al., 2015). The study through film recording can be used to complete other research and qualitative approaches such as interviews and observations of participants (Hammersley, 2018). In interviews, only observers and researchers ask specific questions from participants and record the response, while other aspects of the participants' behavior remain uncertain. However, in video recording, this behavioral dimension of the participants can be repeatedly analyzed by researchers. In interviews and writing, with limited time schedules and official settings limited to a specific phenomenon, in fact, limits the possibility of examining further research dimensions to the researcher. In a similar situation, it is possible to record participants' observations that researchers may be in one field for a limited time, which may also prevent the perceived aspects of the behavior of participants. Furthermore, the study of participants' perceptions and feelings about the subject at various times during the written interviews would be confusing (Brannen, 2017). However, it can be said that the video recording method without an observer is likewise limited by the participants during the interview. For example, the participants that researchers choose to collect data may sometimes remove some data that is unimportant in view of the participant, while this data may be of importance to researchers.

In addition, in this thesis, the number of participants is very small. The results of the investigation in a large group of young children may differ from this small number of kids who participated in this thesis. Thus, for future studies, a large number of participants for more accuracy in the result are suggested.

3.19 Summary

In this chapter, methodological methods for this thesis are presented, both empirically and analytically. For empirical purposes, three methods for conducting qualitative studies in preschool classroom behavior are described and explained in order to cultivate creativity and, on the other hand, enhance their learning potential in STEM. The methods used include semi-structured interviews, videotapes, and checking the participants. For an analytical study, this thesis explains the nature of the approach: ACCT framework based on Vygotsky's sociocultural theory of guiding creative talent and Hughes's taxonomy for expert assessment of existing tools for creativity and learning. User studies focusing on the specificity of creativity and the factors contributing to creativity-enhancing learning in STEM, which is based on the use of a fundamental theory approach and the analysis of data. Evaluating with the aim of identifying factors of creativity and its continuity in raising the level of user learning and its concepts, expands the offer of repeated opportunities and other dimensions. This chapter also discusses important aspects or methods of data collection.

CHAPTER 4: DATA ANALYSIS AND RESULTS OF EXPERIMENT (1)

4.1 Introduction

This chapter describes the findings from the first experimental interview. This chapter explains how to encourage young children to play digital educational games on tablets and determine these features and components of creativity. The relationship between these components was also examined. This qualitative study aims to discover the components of fostering creativity and learning skills in DGBL at the preschool level. In this present case study, seven participants in the preschool level (aged 3-6), two teachers, and seven parents were examined in Malaysia affiliated to Montessori school.

At the beginning of this chapter, methods, examples, and cases used for studies are described. In this chapter, this thesis provides an explanation of the participants in the method of researching and analyzing the data collected from semi-structured interviews, observations, and development artifacts. The findings are summarized prior to providing data and results. This is followed by summarizing the data and results.

4.2 Overview of findings

According to contents were founded in the results of data, the findings are divided into the following sections;

1. DGBL and creativity skills,

2. DGBL and play,

3. Principles of DGBL and pedagogy in applications,

4. The difficulty of the use of games.

In the first stage, the types of creative activities and applications that children use as a creative activity were discussed. This was done after discussing all aspects of creative thinking based on the ACCT framework (Robson, 2014). The most significant growth in creativity was seen in three sections of the "Exploration and engagement" sub-section; "E1: Exploring", "E2: Engaging in a new activity", "E3: Knowing what you want to do". In the second part, according to the characteristics of the game in classifying the factors influencing the development and strengthening of play and creativity in children, it was considered based on the classification of Hughes (Hughes, 2002). The results include things like; "objective play", "exploratory play" and "creative play" which not only enhances children's play but also creativity and learning. Afterwards, in Section 3, the principles of digital game-based retrieval, including creative teaching and creative learning, were examined. The fourth section also describes the difficulty of using games.

4.3 Presentation of the Data and Results

As mentioned earlier, interviews were analyzed by using the inductive analysis model. Also, the observations were analyzed using typological analysis. Throughout the process of analyzing the data from these sources, patterns began to emerge and were sectioned into codes. As a result, 30 codes emerged resulting in four themes, which are presented in the sections below.

4.3.1 Section 1: DGBL and creativity skills

In this section, observations on children's behavior are divided into two categories: (1) DGBL and creative activities, and (2) DGBL and creative thinking.

4.3.1.1 Open Coding, Axial Coding of DGBL and creative activities

As previously mentioned, the nine effective educational games, identified in the Marsh survey (2015; 2018), were analyzed in terms of how far they promoted play and creativity.

This section discusses the observation of activities and apps used by children. To identify support/ features of fostering the creativity of most effectively exiting DGBL apps on creativity.

As mentioned in chapter 2, when children play, their creativity grows more. In fact, it can be said that there is a close connection between creativity and play. Children's play promotes their cognitive development. This is because children's play leads children to acquire new skills, knowledge, and understanding of the world around them. Vygotsky called this activity a "progressive activity" (Vygotsky, 2004).

In this thesis, Hughes's taxonomy was chosen for digital game based learning (Hughes, 2002). The rationale behind choosing this classification was the existence of both small and large details about the types of games. This classification divides the types of games into about 16 types. Another difference existing in this classification is the appropriate definition of the types of games to be adapted to the virtual world and digital games based on education (see chapter 2).

On the other hand, this approach to playing and creativity skills helps the researcher to have a deeper understanding of children's behavior during playing DGBL. This taxonomy can provide a more accurate evaluation by designing and developing ideas and themes and analyzing them.

The analysis of the data shows that the selected apps have been effective in encouraging preschool children to types of play and develop their creativity. Observations and information gathered from teachers in the school environment, as well as parents, indicate that digital games had an important role in supporting children's play and creativity. In this thesis, DGBL and creative activities codes are adapted from the research of Marsh (2015; 2018), based on

the ACCT framework (Robson, 2014), were analyzed in terms of how far children promoted creativities activity (Marsh, Plowman et al., 2015; Marsh, Plowman et al., 2018).

Table 4.1: Open Coding, Axial Coding, and Selective Themes in DGBL and creative activities

Open Codes in **DGBL** and **creative activities**	**Axial Codes From Promoting** Creative Activities in **DGBL Offered**	**Emergent Theme from Promoting** Creative Activities in **DGBL**
Constructing Lego	Constructing	Constructing
Constructing shapes		
Constructing line		
Understanding of Constructing		
Drawing shapes	Drawing	Drawing
Drawing numbers		
Drawing animals		
Drawing plants/ flowers		
Drawing others		
Storytelling	Storytelling	Storytelling
Listen to storytelling and audiobooks		
Reading story		
Look at pictures /photos		
Making Music	Music	Music
Enjoying Music		
Listen to Music		
Painting colors	Painting	Painting
Painting shapes		
Painting numbers		
Painting animals		
Painting plants/ flowers		
Painting others		
Making colleges	Making social skills	
Making social skills		
Making friends		
Taking photographs	Look at pictures /photos	
Watching videos	Watching videos	
Play with/use apps for gaming		
Play with/use apps for social		
To help with learning and education		
Others		

Table 4.1 shows the general overviews of the themes through open coding, axial code, and data collected in this research. These codes are based on data supported by evidence of the promotion of creative activities in this research (see Table 4.1).

In this thesis have cited examples of this project in each of the following sections to further describe and state the claim.

Code of Painting & Drawing:

According to the teachers in the school environment, the feedback provided by preschoolers has strengthened them in some of the skills, such as writing, painting, collage, and other artistic and creative activities.

For example, participant (1)'s teacher **(T1)** said:

"She was a very quiet child. After a while, she started painting and designing in these apps, and this reflects the depth of psychology of creativity in learning. That is, a child who did not have an interest in learning to write, after using these apps has become interested in writing and painting."

In another example, one of the teachers **(T2)** said:

*"**Participant (7)** was a very shy and calm child, and she rarely wrote the English alphabet in class in the traditional way on paper. After watching digital games on the iPad, she became interested in applications. After a while, the **participant (7)** started painting and drawing in these applications."*

In addition, children learn to engage in activities such as painting, drawing, and coloring, watching movies to help with learning and teaching while looking at pictures. Most of the children and teachers have chosen the applications that were more fun for participating

children. In the category and interests of children, it can be noted that children under the age of four were interested in quiet games with less challenge and lower speed. This is when children over the age of four were interested in challenging, high-speed games. The girls were very interested in coloring games. Older children were more likely to play games with creative activities such as photography, drawing, and creative educational games. Younger children chose simpler games such as listening to music, storytelling, and watching movies. Even according to reports from parents in the home environment, after using these apps, the level of designing creatively and learning the alphabet among children has dramatically been increased. Meanwhile, the world of children was understood through apps and tablets used by children. Another teacher **(T2)** said:

*"... **Participant (7)** was a very little child and did not dominate in our language, so through painting and collage in these apps with us interacted more."*

In another example, another teacher **(T1)** said;

*" …**Participant (5)** was a very young child who did not speak English. It was a little difficult to communicate with him before playing with these programs. But he interacted with us mostly through painting and collage in these digital games. He gradually became more familiar with the English alphabet. "*

Code of Storytelling:

In another example, another teacher **(T2)** said;

***"Participant (4)** who became interested in continuing the story by listening to the story. The child showed a strong desire to go to the next slide and continue the story by touching the next button."*

In another example another teacher **(T1)** said;

*"...when the child**, Participant (3)** clicked on the photo, a short story about the photo was played to the child with different slides, which greatly excited the child and encouraged the child to hear the next story.*

Code of Constructing:

The teacher reported the obvious creativity for preschoolers using apps, which used puzzles or construct objects such as Lego or Minecraft. Participant (3)'s teacher **(T2)** said:

"... he has a lot of passion for Lego's application, and he could build a machine by putting different parts like wheels, top, ceiling alone. the app gives him all these parts and he creates a car that is very enjoyable for him and, on the other hand, he develops his creativity."

In another example, one of the teachers **(T1)** said;

*" **Participant (4)** was interested in Minecraft. Some digital games provided him with various parts that by choosing colors and placing parts from different angles, participant (4)'s creativity in constructionism in these applications was subconsciously expanded."*

Code of Music:

Besides, music can also be said to be a key element in young children's creative daily life. And these days in the app market, the trend towards music-based games have also grown (Young, Slota et al. 2012). Children's music apps enable kids to create new songs and listen to a wide range of music. For example, participant (6) was able to create and then heard her song by pressing the buttons on the tablet, which gave her the chance to play through the game.

In another example, another teacher **(T2)** said;

*"**Participant (1)** also created her song by touching the tablet buttons and then listened to it with pleasure and dancing. Apps allow children to get acquainted with music notes and their sound by playing them, and allow children to make a new world of emotions."*

Table 4.2 reviews the number of references for each code perceived in the observations. The amount of references for each code (in each case study) seen in the observations. So, the number of references indicate how many case study (based on the categories of codes) exhibited such behavior during observation. The themes generated by data were supported by observations of teachers, parents, and researchers (see table 4.2).

Table 4.2: **Observations of promoting creative activities in DGBL**

Games Number	Name of DGBL applications	Observation Evidence of Promoting **Creative Activities**	Number of References (Case study)
Game 1	AR flashcard – alphabet & more	Constructing	3
		Storytelling	5
		Music	5
		Painting	6
		Making social skills	2
		Look at pictures /photos	3
Game 2	Meet the animals	Constructing	5
		Drawing	6
		Storytelling	3
		Music	5
		Painting	6
		Making social skills	2
		Look at pictures /photos	3
		Watching videos	1
Game 3	Toca Boca Nature	Constructing	7
		Drawing	6
		Storytelling	7
		Music	4
		Painting	5
		Making social skills	3
		Look at pictures /photos	4
		Watching videos	5

Table 4.2: ***(Continued.)*** **Observations of promoting creative activities in DGBL**

Game 4	Toca Boca Doctor	Constructing	7
		Drawing	6
		Storytelling	7
		Music	6
		Painting	6
		Making social skills	2
		Look at pictures /photos	1
		Watching videos	3
Game 5	CBeebies story time	Constructing	2
		Drawing	7
		Storytelling	7
		Music	7
		Painting	7
		Making social skills	2
		Look at pictures /photos	3
		Watching videos	3
Game 6	Squiggle	Constructing	7
		Drawing	5
		Storytelling	3
		Music	4
		Painting	5
		Look at pictures /photos	3
		Watching videos	3
Game 7	CBeebies play time	Constructing	7
		Drawing	7
		Storytelling	6
		Music	7
		Painting	6
		Making social skills	3
		Look at pictures /photos	3
		Watching videos	2
Game 8	Minecraft	Constructing	7
		Drawing	4
		Storytelling	3
		Music	3
		Painting	2
		Making social skills	3
		Look at pictures /photos	2
		Watching videos	2
Game 9	Peppa pig collection(Paint box)	Constructing	7
		Drawing	7
		Storytelling	7
		Music	7
		Painting	7
		Making social skills	4
		Look at pictures /photos	3
		Watching videos	2

4.3.1.2 Selective Themes of DGBL and creative activities

According to table 4.2 and figure 4.1 that illustrate an overview of the number of references for each code seen in the observations, the themes that emerged through supporting data from the teacher, parents, and researcher observations. The feedback of these applications provided by preschoolers has strengthened them in some of the skills, such as painting, drawing, constructing, storytelling, and music artistic and creative activities (see figure 4.1).

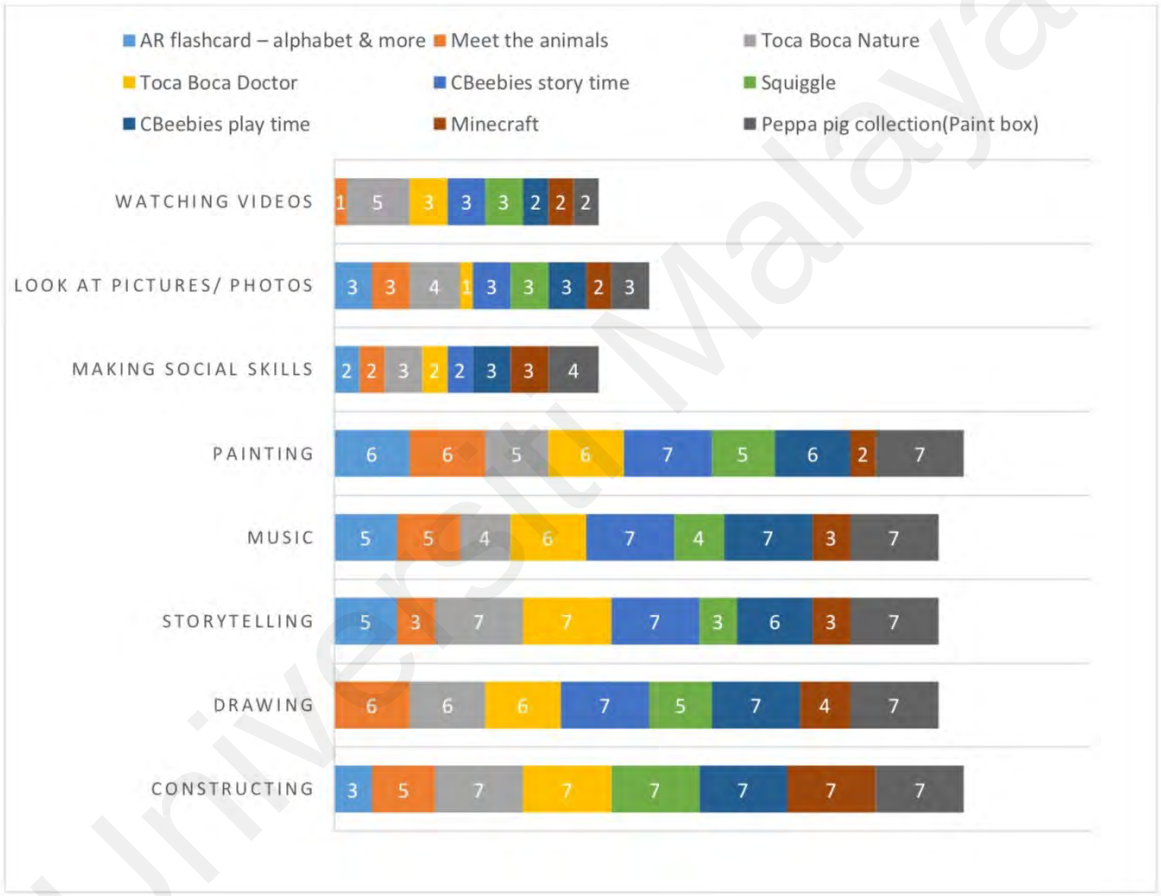

Figure 4.1: Observations of promoting creative activities in DGBL at the preschool level

Findings indicate that children are encouraged to play and cultivate creativity after playing with selected applications. Several overarching patterns emerged from the data for creative activities. As a result of creative activities from using selected application among preschool level children, the following themes emerged from the data:

1. Teachers and parents emphasized that digital games, due to the attractiveness and interaction they have with children, cause children to spend more time playing with them, and this is also involved in fostering children's creativity.

2.. Most of the children's creative activities have been observed in digital games, which had topics or sections such as storytelling, interactive and visual books, painting, and coloring.

3. Teachers and parents also noted that children after playing with several digital games selected have good progress in some skills such as writing, painting, collage, and other artistic and creative skills. This shows the profound psychological impact of these digital games on the psyche of children, in terms of play on the creative mind and thought process of children in the subject of learning. In this way, children become interested in writing the letters of the alphabet using these digital games and practice more. Teachers and parents also confirmed that children have made good progress in learning the alphabet after playing with these applications.

4. Children have a deeper connection with their parents, teachers, and even their peers with these apps. Because children often asked their peers, parents, and teachers for help and guidance in doing applications, this has caused teachers and parents to be closer to the world of children.

5. Some applications such as Lego and Minecraft cause a significant increase in creativity (especially in constructing) in children.

6. From the world of art, music also plays an important role in the world of children. Listening to music made by the children themselves is enjoyable for children and opens a new world of art to them. In the digital space, these applications show children this capability of the world of music art, encouraging them to use and entering the world of music art.

4.3.1.3 Open Coding, Axial Coding of DGBL and Creative Thinking

This thesis first describes the observations of children in two groups of creative activities and creative thinking in DGBL applications. In the previous section, the researcher explained the first part as to creative activities. In this section, this thesis describes the findings of the second part as to creative thinking. These findings have been examined and identified in three main components based on Robson's (2014) Framework(Robson, 2014):

E: Exploration

I: Involvement &Enjoyment

P: Persistence.

Each of these activities will be described below. In each sub-section, the activities, categories, and types are defined. This thesis also cites some examples of this project in each of the following sections to further describe and state the claim.

Table 4.3 shows the general overviews of the themes through open coding, axial code, and data collection of creative thinking and DGBL in this research. These codes are based on data supported by evidence of the promotion of creative activities in this research (see table 4.3).

Table 4.3: **Open Coding, Axial Coding, and Selective Themes in DGBL and CT**

Open Codes DGBL & Creative Thinking	**Axial Codes** Promoting Creative Thinking in DGBL Offered	**Selective Themes** Promoting Creative Thinking in DGBL
	E: Exploration	
• Tending to discover a challenge • Tending to discover an activity • Tending to discover of a substance	E1: Exploring	E1
• Ready to get involved in an activity • Ready to come up with an idea	E2: Engaging in the new activity	E2
• Enjoyment of being curious during using game • Enjoyment of being curious in choosing a game • Enjoyment of being curious in learning a game • Enjoyment of being curious in choosing environment in a game • Enjoyment of being curious in choosing character in a game	E3: knowing what children want to do	E3
	I: Involvement &Enjoyment	
• Finding a new path to obtain an idea • Using previous or new knowledge to obtain an idea or hypothesis	I1: Trying out ideas	
• Providing an idea • Making a decision whether or not to pursue an idea	I2: Analyzing ideas	
• Expressing opinions • Expressing about his/her activity • Asking teachers or friends about their activity • Involving & engaging with other children	I3: Speculating	

Table 4.3: ***(Continued.)***

Open Coding, Axial Coding, and Selective Themes in DGBL and CT

• Involving & engaging with adults • Involving with other to develop an idea • Engaging with other to develop an activity	I4: Involving others
	P: Persistence
• Resistance to the game • Enduring the ambiguity of the game • liking to play game while did not understanding steps of game	P1: Persisting
• Taking risks to do challenge • Taking risks to do answering questions in game • learning from mistakes during using game • Taking risks to draw and learning from mistakes • Taking risks to painting and learning from mistakes • Taking risks to draw alphabet and learning from mistakes	P2: Risk taking
• Believing in own self • Expressing a sense of self-efficacy • Expressing a sense of self-esteem • Joy of finding solutions to challenges	P3: Completing challenges

4.3.1.3.1 Codes of Exploration

This component comprises three sub-components:

E1: Exploring,

E2: Engaging in the new activity,

E3: knowing what you want to do.

In this thesis for explaining every sub-component have cited examples of this project in each of the following sections to further describe and state the claim.

Code E1: Exploring

As an adapted definition, according to Robson's framework, it is explained that the child is interested in discovery and tends to discover the potential of a challenge, activity, or substance (Robson, 2014).

For example, in this project, one of the teachers **(T2)** said about participant (1)**:**

"...She tried to play the game buttons on the tablet so that she could understand the rhythm of the game. She showed that she enjoyed it and went on to discover the next step. The shapes and attractiveness of the game stimulated her and gave her more motivation to continue playing."

For example, participant (4)'s teacher **(T1)** said;

"...he touches the game's menu buttons on the tablet to understand the rhythm of the game. He showed that he wanted to play it, and the shapes and charm of the digital game space encouraged him to play more."

In another example, teacher **(T2)** said:

*"**Participant (3)** while playing Minecraft was trying to choose different pieces to build a tree. Exploring the small and large pieces helped him to understand the rhythm of the game and the difference in the size of the pieces and their shape."*

In another example seen in the video:

*"**Participant (6)** tried to search and explore to choose the right shape to replace the blank. She dragged with his finger at all the triangle, square and rectangular shapes in the triangle blank space. After repeated attempts to understand the rhythm of play and find out which space is in the triangle, she sent the triangle to the empty space. She was very happy that the triangle fell into the right place on the screen."*

Another example of this code, teacher **(T2)** pointed out:

*"...**Participant (7)** 's effort to explore the shape of the fruit. A child who tries to show a watermelon with a circle and seeks to draw the shape of a circle or to find the shape of a circle and paint it green, says that he has drawn a watermelon."*

In another example, teacher **(T1)** said:

*"...connecting the letters of the alphabet and exploring to find fruit and similar shapes was a challenge for children that were seen in applications. For example, after trying to write the letter A, **Participant (2)** was encouraged and curious to explore by the teacher as to which fruit starts with the letter A, such as apple fruit."*

Code E2: Engaging in the new activity

In defining this component in the afore-mentioned framework, the child is ready to get involved in an activity and comes up with an idea. This activity can be at the child's own discretion or suggested by another child or by an adult (Robson, 2014). One example to be found in this project to match the definition of this component is the example of participant (3)'s activities.

As an example, the teacher **(T1)** in this project said about participant (3):

"He watches other children play with the app where painting and coloring are used. He approaches those children and tries to pick a color with his finger. Drawing his hand on the tablet screen it will turn yellow to spread. "

An example refers to the combination of shapes by children, the teacher **(T2)** in this project said about participant (7):

"…by putting shapes such as squares, triangles, and circles to engage themselves in a new activity and idea. In this activity, the application asks them what combination is close to which animal or fruit. Like when a child puts a circle and a triangle together. He puts a triangle at the top and a circle at the bottom, and they happily say that my compound shape is a pear."

The teacher **(T2)** in this project said about participant (6):

"…she comes up with an idea by drawing a circle and turning it yellow."

The teacher **(T2)** also said another example about participant (1):

"… is the placement of Minecraft pieces, which shows that the child has been drawn to a new activity and idea."

The teacher **(T1)** said about participant (4):

"...he tries to achieve the desired compositional concept by assembling the shapes. He made a machine from Minecraft parts and showed it to the teacher."

In another example, the teacher **(T1)** referred to participant (5):

"...he first draws a shape while painting and then changes his activity by choosing a different color. At the encouragement of the teacher, he is drawn to a new activity. He likens the shape to one of the fruits. He first painted a relatively long triangle and then painted it orange. The child attributes it to the carrot fruit."

Code E3: knowing what you want to do

In this case, what Robson has defined in his framework reflects a child's enjoyment when choosing a game out of curiosity (Robson, 2014).

An example that can be said to be compatible with the project is " participant (5)" whose teacher **(T1)** in this project said:

*"...When **participant (5)** is playing a game of building an app designed for the tablet, he points his finger at the next piece which he wants to choose as the next piece to make."*

In another example, teacher **(T2)** in this project said:

"...While playing with applications, this pleasure and curiosity to continue playing was well observed in children, who in some cases even had a strong desire to continue playing and cooperating with each other."

Teacher **(T1)** said:

"In the other case, the child who was learning the letters immediately after the letter C, out of curiosity, searched for the animal related to the letter C, namely the cat."

In another example teacher **(T2)** said of **participant (5)**:

"...As a child, he chose yellow and immediately chose pear fruit because of its yellow color. The interest in continuing the game and the curiosity to find the next stages of the game was clearly seen in the children."

Teacher **(T1)** said of participant (1) as another example of this code:

"...is the connection of body parts to writings, such as which writing indicates "hand" and where to connect. Immediately after seeing the shape of the hand, the child touches it towards the writing part. The child was found to be interested and curious to discover other parts of the human body."

Teacher **(T2)** said of participant (5) in the storytelling section:

"...the child's curiosity to choose and continue playing was observed. The child had to touch the arrow icon on the next page button to continue listening to the story. After listening carefully to the story, the child happily touched the continue button to link to the next page of the story with his finger."

4.3.1.3.2 Codes of Involvement and enjoyment

This component also enjoys four sub-components, each of which is explained with an example:

I1: Trying out ideas,

I2: Analyzing ideas,

I3: Speculating,

I4: Involving others.

Code I 1: Trying out ideas

In the definition of this component in the ACCT framework, it is explained that the child shows evidence of finding a new path, using his/her previous as well as new knowledge to obtain an idea or hypothesis or to show the extent uses flexibility or originality of thinking (Robson, 2014).

In this case, what the project adapts closely to this definition is an example of participant (2) seen in the film;

"He chooses a green triangle and a red circle then juxtaposes them. He declares that this is a tomato, pretending to eat it."

For example, participant (1)'s teacher **(T1)** said:

"... she chose an orange triangle and a green triangle, and then put it together and said it was a carrot and pretended to eat it."

Another example of this is in the Minecraft application. Participant (5)'s teacher **(T1)** said:

"...The child builds the house with the knowledge of how a building is made of different blocks."

Another example participant (6)'s teacher **(T2)** said:

"…. children's prior knowledge of human organs and the proper connection of limbs is important. She knows how to connect sections of the human body together."

Or in another example participant (3)'s teacher **(T2)** said:

"…having previous knowledge that the child has received from his environment and knows that the tree has green leaves. Selecting green and dragging it on the iPad screen indicates that the tree is drawn with green leaves. By choosing other colors of yellow-orange, the child emphasizes that the yellow and orange colors show the autumn leaves. He points with his hand as the leaves fall to the ground."

Code I 2: Analyzing ideas

When the child shows verbal evidence or behaviors that he/she has come up with an idea, he/she decides whether or not to pursue it (Robson, 2014). For example, in this project, an example of child behavior that is consistent with this definition.

Participant (4)'s teacher **(T1)** stated:

"…while he is painting a road (in an application capable of painting), another child with his finger painted the blue spot in front of his road and stated that it was a lake.

Participant (4) told the child that he had painted this path for the car to go and the other child drew the blue lake to block the road."

In another example, Participant (4)'s teacher **(T1)** said:

"…the child has chosen a rectangle. Below it is two smaller circles. He excitedly shows the teacher his composite form. He says he pulled a car in different shapes."

Or in other case, Participant (3)'s teacher **(T1)** said:

"... a child who tries to draw an apple shows that he knows the example for the letter A and says that what he has drawn is a red apple."

Code I 3: Speculating

The child expresses his/her opinion and asks the teachers or friends about their activity. An example of this definition can be seen in the following example that one of the teachers **(T1)** said:

*"**Participant (1)** was playing an educational game, then she asks me about her drawing."*

Participant (1): *"What is this like?*"

Teacher: "*You drew a shape that looks like a triangle."*

Participant (1): "*Yes, but why this is a triangle?"*

Or in other case, Participant (2)'s teacher **(T2)** said:

"...The child finds the dog to talk to the animal. He drags the letter D on the shape of the dog with his finger. He tells the teacher that he knows the dog that starts with the letter D and asks teacher to tell him an example of another animal that starts with D."

Another example is about Participant (5). Teacher **(T2)** said:

".... The child chooses a circle and says that the shape of the apple, orange and watermelon is like a circle."

In an example of a storytelling app, the teacher (T1) said:

"...sometimes I stop the story while the story is playing and asks the children if the children know what happened next. Each child expresses their idea to continue the story. Like a child

***Participant (1)**, who tells the story that the protagonist goes to buy vegetables with his mother."*

Code I 4: Involving others

The child engages with other children or adults to develop an idea or activity. The child may express an idea, as well as expresses his/her acceptance of the ideas of other children or adults.

An example of this definition can be found in this project;

*"While **participant (3)** and participant (5) are playing.*

***Participant (3)** said: "I want to color yellow this part."*

*While **participant (5)** said: "No, I want to paint it yellow."*

***Participant (3)** said: "you can paint the other side of the shape yellow"*

.... and they both continue to play paintings on the tablet."

The following is another example of participant (5)'s behavior that was recorded after watching the movies and observations;

*"**Participant (5)** was looking at the other kids as they played with a painting application. Then he put his finger on the tablet's touch screen and told the other child sitting next to him with a satisfying smile that it was the sun."*

Another example is when participant (4) is drawing a shape.

"He shows the picture to his friend and his friend asks: What is this? He says a tree leaf. His friend says let's paint it. They choose green to paint it. He and his friend paint with their finger on the iPad screen."

4.3.1.3.3 Codes of Persistence

This component is also composed of four sub-components, each of which is explained (by this thesis) with an example:

P1: Persisting,

P2: Risk-taking,

P3: Completing challenges.

Code P1: Persisting

Despite the challenges and difficulties in the game, the child shows resistance to the game, enduring the ambiguity of the game.

For example, in this project, one of the teachers **(T1)** said;

"In an application, ***participant (6)*** *drags the fruit into a glass container with a finger. Suddenly the fruit is thrown out of the container. He continued to be careful, smiling, and not knowing why this happened, he did not lose focus. Again, he put the fruits in the container."*

In another example, teacher **(T1) said:**

"... another ***participant (6)*** *said that when the story was over, the child would touch the scroll button icon to continue and listen to the story."*

In this case, what the project adapts closely to this definition is an example of participant (4) has seen in the film.

"...When the child tries to put any shape like a square in a triangle in their empty space. The figure returns to its previous position several times when it is abandoned by the child. But the child again puts his finger on the shape and pulls it to the right place."

Code P2: Risk-taking

The child tends to take risks and learn from his mistakes.

For example, in this project one of the teachers **(T1)** said;

*"**Participant (3)** was feeding animals in a game on the tablet. He chose a cat. Then, he cut meat and fish and put it on the cat's plate to eat, and the cat ate! Then, he tried to put an insect as food on the plate, but the cat did not eat that. Participant (3) found that if he chose meat and fish as the food, cats can eat them! "*

The numbers game is another example of participant (2) has been seen in the film.

"*When the child puts the wrong number under the pictures. The game does not encourage him and the child realizes that he has put the number below the number of shapes incorrectly. So he chooses a number again. He tests the risk of choice. This time, make sure the app's applause sounds right. The child's smile indicates his or her satisfaction with the risk of choosing to find a solution to the challenge."*

In another example, in this project one of the teachers **(T1)** about participant **(4)** said;

"*… The child chooses different colors to paint the shapes and at the same time with each choice, he challenges a new risk to his liking. He explains by his choice that he wants the circle to be yellow, not blue. Because the sun is circular and yellow.*"

In another example, in this project one of the teachers **(T1)** about participant **(5)** said;

"…the other child likes to make the triangle yellow. He turns the triangle green again. He says it's like green. The triangle is like the leaves of trees, so it should be green."

Code P3: Completing challenges

The child believes in himself/herself and expresses a sense of self-efficacy, self-esteem, and the joy of finding solutions to challenges.

For example, in this project,

*"...a teacher **(T1)** was working with a child (participant (1)) in the alphabet field. The child happily says: "I wrote A". The teacher looks at her in admiration. The child once again puts the letter A on the tablet and painted it with her finger, smiles, and shouts aloud happily "I wrote A again!""*

Table 4.4 reviews the number of references for each code observed in the observations of promoting creative thinking in DGBL applications. The amount of references for each code (each case study) seen in the observations. So, the number of references indicate how many case study (based on the categories of codes) exhibited such behavior during observation. The themes generated by data supported by observations of teachers, parents, and researchers (see table 4.4).

Table 4.4: Observations of promoting creative thinking in DGBL applications

Games Number	Name of DGBL applications	Observation Evidence of Promoting **Creative Thinking Components**	Number of References (Case study)
Game 1	AR flashcard – alphabet & more	E1	4
		E2	6
		E3	5
		P1	2
		P3	1
		I1	2
		I2	2
		I3	2
		I4	1
Game 2	Meet the animals	E1	5
		E2	5
		E3	4
		P1	1
		P2	1
		P3	1
		I1	2
		I3	3
Game 3	Toca Boca Nature	E1	4
		E2	4
		E3	5
		P1	1
		P2	2
		P3	1
		I1	1
		I2	2
		I3	1
		I4	2
Game 4	Toca Boca Doctor	E1	4
		E2	5
		E3	3
		P1	2
		P2	1
		I1	1
		I2	1
		I3	1
Game 5	CBeebies story time	E1	5
		E2	5
		E3	5
		P3	2
		I1	1
		I3	2
		I4	1

Table 4.4: ***(Continued.)*** **Observations of promoting creative thinking in DGBL applications**

Game 6	Squiggle	E1	6
		E2	5
		E3	1
		P1	1
		P2	1
		I1	2
		I2	1
		I3	1
		I4	3
Game 7	CBeebies play time	E1	3
		E2	4
		E3	4
		P1	1
		P2	3
		P3	1
		I1	1
		I2	3
Game 8	Minecraft	E1	5
		E2	4
		E3	4
		P1	2
		P2	1
		P3	1
		I1	1
		I2	1
		I3	1
		I4	1
Game 9	Peppa pig collection(Paint box)	E1	5
		E2	4
		E3	5
		P1	1
		P2	1
		P3	2
		I1	2
		I2	1
		I3	1
		I4	1

4.3.1.4 Selective Themes of DGBL and Creative Thinking

The children were more interested in exploring. In some games, they tend to discover a challenge and an activity. These apps encourage children to ask their teachers, parents, or peers to accompany, play, and sometimes even get help. It also subconsciously affects children's social skills and social communication after stimulating their activities.

In the next part of the observation, this thesis indicates that there were a deep interaction and connection in digital games (installed on the iPad) with children. This evidence also proves that such games stimulate the imagination and curiosity of children. In the next step, children try to identify the new knowledge presented in the games by using their previous knowledge.

Observing the children's behavior indicates that they try to present a new hypothesis or idea using the previous knowledge and new knowledge provided in the applications. This shows the children's inclination to creative and critical thinking and intellectual flexibility to the originality of divergent thinking.

In summary, the study employs applications to provide a broad view of children's creativity such as creative thinking, problem-solving, curiosity, exploration, and the like.

As illustrated in table 4.4 and figure 4.2, an overview of the number of references for each code can be seen in the observations and the themes emerge through supporting data from the teacher, parents, and researcher's observations.

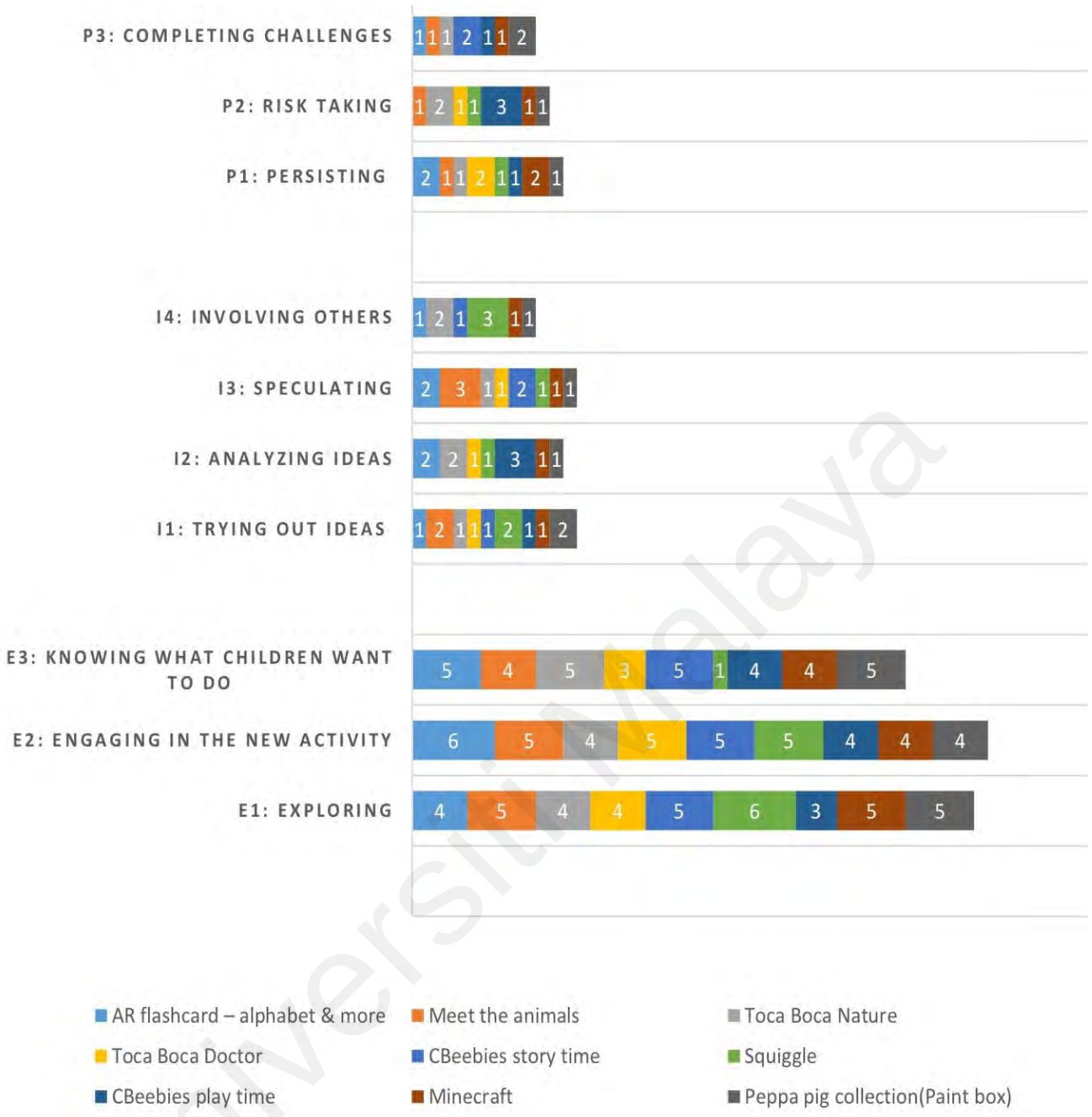

Figure 4.2: Observations of promoting creative thinking in DGBL application

The feedback of these applications provided by preschoolers has strengthened them in some of the creative thinking skills. Therefore, based on the ACCT framework, the three most significant and obvious parts of the subcategory are “Exploration and engagement” topics, showing that it has played a greater role than other themes and the development of children's creativity and learning (Robson, 2014);

E1: Exploring,

E2: Engaging in the new activity,

and E3: knowing what you want to do (see figure 4.2).

4.3.2 Section 2: DGBL and play activity

As pointed out in Chapter 2 introduces the taxonomy and example for the per types of play.

4.3.2.1Open Coding, Axial Coding of DGBL and play activity

Table 4.5 shows the general overviews of the themes through open coding, axial code, and data collection of promoting play activities and DGBL in this research. These codes are based on data supported by evidence of the promotion of creative activities in this research (see table 4.5).

Table 4.5: **Open Coding, Axial Coding, and Selective Themes in DGBL and play activities**

Open Codes in **DGBL and Play Activity**	**Axial Codes From Promoting** Play Activity in **DGBL Offered**	**Selective Themes from Promoting** Play Activity in **DGBL**
• Making one piece to another to create an object in an application. • Making one piece to another to create a creature in an application.	Symbolic play	

Table 4.5: ***(Continued.)***

Open Coding, Axial Coding, and Selective Themes in DGBL and play activities

• Using a tablet for playing digital applications • Playing with each other in applications • A cooperative and energetic play in applications	Rough and tumble play	
• Real-life scenarios • Personal narratives	Socio-dramatic play	
• Interacting in application • Encouraging social interaction in game	Social play	
• Exploring in game • Developing ideas in game • Developing things in game.	Creative play	Creative play
• Play with words • Play with songs • Play with rhymes • Play with lyrics • Play with etc.	Communication play	

Table 4.5: ***(Continued.)***

Open Coding, Axial Coding, and Selective Themes in DGBL and play activities

• Playing for performances that are not directly on television	Dramatic play	
• Moving in a game • Chasing in a game • Hiding in a game • Searching in a game	Deep play	
• Facing with challenging experiences • Feeling must be fought for survival	Locomotor play	
• Playing all senses by searching for objects through the information available in the game. • Playing all senses by searching for environment through the information available in the game.	Exploratory play	Exploratory play
• Playing in roles that do not exist in real life • Playing roles as superheroes • Playing roles as main character in game	Fantasy play	
• Pretending to be something else in game	Imaginative play	
• Trying to control all the components of the environment of the game • Trying to rebuild something in an environment of game	Mastery play	

Table 4.5: ***(Continued.)***

Open Coding, Axial Coding, and Selective Themes in DGBL and play activities

• Playing with objects that involve senses • Playing with objects that involve touch and vision	Objective play	Objective play
• Playing in personal roles • Playing in domestic roles in family	Role-play	
• Discovering rituals with myths • Discovering history in game	Recapitulative play	

This section of the thesis re-explains 16 types of play based on Hughes' taxonomy with examples (Hughes, 2002):

1. **Symbolic play-** According to Hughes, when children feel from making one piece to another piece, they create an object or creature, for example, something similar to a horse, etc.

For example, in this project one of the teachers **(T1)** said;

*"**Participant (3)** put a rectangle and two circles together and happily said he had built a car. **Participant (1)** put a rectangle and a square together and happily said he had built a house. **Participant (4)** pointed to the juxtaposition of an orange triangle next to a green circle designed by a carrot. **Participant (2)** was painting with blue lines, noting that these connected blue lines represent the river."*

2. **Rough and tumble play-** When kids are playing with each other and physically interacting with each other during the game, it is not an aggressive touch. It is an energetic game that children can play with each other.

However, due to using a tablet for playing games in this project, there is no physical contact process for children; it is only possible to explain the existence of a cooperative and energetic play for this case.

For example:

*"It is when the children **(Participant (4) and Participant (5))** take paint with each other. They complete the painting with great energy."*

*"**Participant (1)** and her friends take paint with each other. They complete the painting with great energy."*

*"When children **(Participant (2))** ask the teacher to show them the continuation button in the app to touch the continue button so that they can touch them."*

3. **Socio-dramatic play-** Real-life scenarios like going home and shopping.

For example, in this project, one of the teachers **(T1)** said;

*"**Participant (3)** imagines himself as a pet doctor and wants to treat animals with an app. At all stages of the game, he considers himself a responsible physician who is striving to save the lives of animals."*

*"**Participant (1)** tries to pretend to be the mother of one of the characters in the app. She takes care of him. He enters the character room. It wakes him up and feeds him. He bathes her and tightens her clothes."*

4. **Social play-** A game that has rules for interacting and encouraging social interaction.

For example, that has been seen in the recorded video:

"In this project, playing a group of kids to build a simple building with simple squares, where the tablet is passed from one child to another child to put the next square."

In another example has been seen in the recorded video:

*"Collaborative coloring among children is an example of this. One child, **participant (2)**, paints a part of a tree and the next child, **participant (1)**, paints the leaves of the tree and the other child draws red fruits for the tree and says that this tree is a red apple."*

5. **Creative play-** A game that takes children to explore, develop ideas and things.

The definition of this component of the play was adapted in this project like a digital game that encourages the child to build a building from the main shapes (such as triangle, circle, square, and rectangle) and teacher **(T1)** regarding this example said:

*" **Participant (6)** made a building with square and triangle and said with excitement and enjoyment that she built a house. **Participant (2)** was encouraged to build a building from the main shapes (such as triangle, circle, square, rectangle) by an application and she says with excitement and joy: "Look, I've built a house."*

Or some examples have been seen in the recorded video:

*"A child, **participant (4)**, puts a brown rectangle and then a green circle next to it and says I made a tree. The other child, **participant (3)**, gets different colors by mixing colors in the application. For example, it uses blue and yellow together in the application and it turns green. In the other case, a child, **participant (1)**, who tries to draw an animal in different shapes with several circles, triangles, and rectangles next to each other points*

out that he has drawn the dog. Another example is a child, ***participant (5)****, who thinks he has designed a robot by connecting Minecraft parts. "I made a flying iron robot in the app," he says. A child,* ***participant (7)****, tries to make his own music by combining different notes in the app and calls his song "Love Friend forever"."*

6. **Communication play-** Play with words, songs, rhymes, lyrics, etc. The component of the communication game in this project is defined as a digital game that provides the rhythm of words, poetry, etc. in a digital environment for kids. This type of digital game can be played through a puppet or mimicry character. The apps encourage the child to interact and follow the game.

   Teacher **(T1)** regarding this example said:

*"...****Participant (3)*** *played with the rhythm of words, poetry, etc. in a digital environment"*

Or some examples have been seen in the recorded video:

"For example, ***participant (7)*** *tries to draw the letters of the alphabet correctly. After drawing each letter of the application, the pronunciation of each letter is also played with sound. The child repeats it by interacting with the application. After each repetition of the child, the child's learning of the alphabet increases."*

".... In another example, ***participant (4)*** *and* ***participant (5)*** *play with the rhythm of poetry and music to learn numbers. Children repeat the poem in the app, count the number of balloons, and answer."*

Teacher **(T2)** regarding this example said:

"... the child's communication and interaction in the application occurs when ***participant (1)*** *hears and repeats the name of each animal with the touch of a finger on*

the tablet. With each correct touch, the name of the animal, a special sound of joy and encouragement is heard from the application. The child will be happy to hear the sound of applause in the app and will happily shake his hands."

7. **Dramatic play-** Playing for performances that are not directly on television.

   For example, in this project, it can be defined as playing in a digital environment where the child, without practicing reality, plays a role in the digital environment rather than a character (such as television shows).

   Some examples have been seen in the recorded video:

   "…. participant (2) *without practicing reality, plays a role in the digital environment rather than a character (such as television shows)."*

   "…participant (1) *and* ***participant (3)*** *play takes place instead of the main characters of the story in common applications. When the child begins to play by personalizing the play space and characters. For example, as an animal doctor, he examines animals. He checks the symptoms of animals such as fever, etc., and in the role of veterinarian, he plays his full role well."*

   Teacher **(T2)** regarding this example said:

   "…In another example, when ***participant (5)*** *is responsible for taking care of the characters in the app. He has to play the role of a parent in a character in the application. This is when he tries to play the role of a conscientious parent. He feeds the character and takes care of him."*

8. **Deep play-** A game that involves moving, for example, chasing, hiding, and searching. In this thesis, some adaptation of this component's examples has been seen in the recorded video:

*"For example, the game character was hidden somewhere in the digital game environment and the **participant (1)** had to find that character when playing.…In another application, the photo of the animal was hidden under the written word, and the **participant (7)** put his finger on the text of the animal's name, the animal's voice was played and the photo of the animal was displayed."*

Teacher **(T1)** regarding this example said:

*"When the application asks the **participant (3)** to learn how to draw the letters of the alphabet by dragging on the letters. He therefore asks the child to begin the first movement from top to bottom, and then to act from left to right in the second movement. In this type of interaction of the child with the application, due to the deep connection and deep play of the child with the application, the child was well immersed in the game. He learned how to draw the letters of the alphabet."*

9. **Locomotor play-** In the definition of this component, the child is faced with challenging experiences that he/she feels must be fought for survival.

In this thesis, some adaptation of this components' examples have been seen in the recorded video:

*"The digital play where the **participant (3)** is confronted with the challenging play which character of application has to do risky things to survive…. In another example when the **participant (7)** has to point the finger at the screen to show the path to the*

character. He moves the game character by swiping left and right or up and down on the screen. The movement of the child's fingers caused the child to face the challenges of the game through the characters of the applications and also affected the child's emotions."

Teacher **(T2)** regarding this example said:

*"... when the **participant (6)** is taking care of the character of the application so that he can receive more rewards. The challenge of being hungry and taking care of the character is a challenge that the child has to take care of with the application's character. He chooses food for the character and gives it to the character. After each rejection of each challenge, the sound of encouragement and reward in the app caused a satisfied smile on the child's lips."*

10. Exploratory play- This component includes games in which children play with all their senses by searching for objects, spaces, and so on through the information available in the game. This component is easily adaptable to the project of applications and digital games.

Some adaptation of this component's examples has been seen in the recorded video:

*"...In digital space of games, in which **participant (5)** searches and discover objects, environments, etc. in cyberspace through the information gained in the game."*

11. Fantasy play- Children's role-play that does not exist in real life, such as superheroes.

Some examples have been seen in the recorded video:

*"...in applications where the **participant (7)** was identified and screened by a character on the screen and engaged in the activity."*

*"...Another example of this type of play is when **participant (5)** plays the role of a parent or caregiver of the character, it appears well. He knows he has to take care of the game character like his mother. Feed him, put the game character to sleep or take him to the bathroom."*

*".... when the app calls the **participant (4)** 's name and asks him to move by tapping the icon on the screen to recognize the correct letters. In this case, too, the child imagines with the help of his imagination that the application, like a friend or a teacher, calls him and asks him for help. The child must move correctly like a superhero in order to save the game character."*

Teacher **(T1)** regarding this example said:

*".... For example, for the letter of the alphabet A, the **participant (2)** is asked to draw the fruit of the letter. By drawing the apple shape, he shows that he has communicated with the application."*

12. Imaginative play- Playing games with children in a way that pretends to be something else. In this thesis, some adaptation of this component's examples has been seen in the recorded video:

*"...**participant (2)** used a circle shape as an apple fruit to feed the digital game character!"*

*".... **participant (5)** is painting. By dragging the rectangle, he pretended to pull the car and made the sound of the car moving. While another **participant (4)** pretended to draw an animal by drawing a rectangle. Then he put four small lines under it and said it was a cow."*

Teacher **(T1)** regarding this example said:

*"... **participant (7)** pretends to be the character's mother in the app and starts talking to the character: Are you hungry? Do you want food? I will bring you food now."*

13. Mastery play- Playing in an environment where the child tries to control all the components of that environment and tries to rebuild it.

As an example in this project;

*"... it can be adopted when **participant (7)** plays a DGBL app like "Minecraft", to match shapes together by controlling and building them in a digital environment."*

Teacher **(T2)** regarding this example said:

*"... playing with a character for which **participant (2)** chooses a specific outfit. Gives him specific food. At a specific time, he puts the character to sleep or wakes him up and takes him to the bathroom. He also plays with characters at specific times. This type of game, in digital games can be an example of mastery game in which the child dominates the entire game environment and can easily change the factors necessary to control the game."*

Teacher **(T1)** regarding this example said:

*"...Another example is the use of different colors in painting. **participant (3)** and **participant (4)** use their favorite colors to draw in a digital environment and draw the shape they have in mind on a digital screen. Then they paint the desired parts with their desired color, which can also be a kind of master bridge that the child has the ability to make changes in all components of the environment."*

14. Object play- In the definition of this component, the child is ready to play with objects that involve the child's sense of touch and vision. In this project, the adoption of this component has been:

*"...when **participant (2)** will see the digital game and its environment and use their tactile sense by placing their fingers on the tablet screen."*

Teacher **(T2)** regarding this example said:

*"...In most digital games, children continue to play by touching the screen and in fact "objective play". Like when **participant (3)** selects different clothing icons for the character with his finger."*

*"... In another example, when **participant (4)** drags a character with the finger in different directions on the screen.*

Teacher **(T1)** regarding this example said:

*".... In another example, I can mention the movement of the car on the screen according to the defined system of the game by moving the iPad left or right, up or down in **participant (1)**."*

*".... Another example is Minecraft, in which **participant (2)** touches a piece of the screen with his or her finger to select it and then drags it to the junction with the finger. "*

15. Role-play- Children acting in personal and domestic roles that are not considered to be a major role. In a digital game, this component also occurs when the child plays a supporting role in the game. Teacher **(T2)** regarding this example said:

"… kids must equip the "auxiliary characters" to help the main character to win the competition in the digital game. ***Participant (1)*** *played a supporting role in the main character in an application and must be equipped with the main character or contribution to help him or her win."*

Some adaptation of this component's examples has been seen in the recorded video:

*"…. **participant (5)** helps the main character and draws the letters of the alphabet on the main figure. He points his finger at the letters of the alphabet A by dragging his finger on the letters. He causes the character to move all the way correctly in the direction defined in the application.…when **participant (2)** tries to play the role of a doctor and perform the necessary check-ups for each animal in the auxiliary work application….. the role of **participant (1)** in buying food such as vegetables, fruits or meat from the virtual store in the app itself. The child buys food to take care of and feed the character. "*

16. Recapitulative play- Playing with children in a game where they may discover rituals with myths and history.

In this project, this component can also be exemplified in digital games in which:

*"…. the **participant (1)** is introduced to the elements of a museum and the intricacies of the historical place…In another example, **participant (3)** can gain access to the early stages of human evolution in a digital gaming environment…In another game, **participant (5)** enters the virtual space of the museum and gets acquainted with each of the museum objects. By clicking on any object, the child will find out the date of finding that object or other definitions…"*

Teacher **(T2)** regarding this example said:

> *"..., **participant (2)** enters a virtual space of the museum and there gets acquainted with the skeletons of dinosaurs, their stages of growth and development…"*

Regarding the observation of types of play in digital environment, table 4.6 reviews the number of references for each code observed in the observations of promoting play activities in DGBL applications. The amount of references for each code (each case study) seen in the observations. So, the number of references indicate how many case study (based on the categories of codes) exhibited such behavior during observation. The themes were generated by data-supported from observations of teachers, parents, and researchers (see table 4.6).

Table 4.6: Observations of promoting play activities in DGBL apps

Games Number	Name of DGBL applications	Observation Evidence of the most Promoting **Play activities**	Number of References **(Case study)**
Game 1	AR flashcard – alphabet & more	Socio-dramatic play	2
		Social play	2
		Communication play	2
		Exploratory play	7
		Objective play	6
Game 2	Meet the animals	Communication play	1
		Exploratory play	6
		Imaginative play	1
		Mastery play	1
		Objective play	4

Table 4.6: *(Continued.)* Observations of promoting play activities in DGBL apps

Game 3	Toca Boca Nature	Symbolic play	1
		Socio-dramatic play	1
		Creative play	5
		Exploratory play	6
		Imaginative play	5
		Objective play	5
Game 4	Toca Boca Doctor	Symbolic play	1
		Socio-dramatic play	2
		Social play	2
		Creative play	3
		Communication play	2
		Deep play	1
		Exploratory play	6
		Imaginative play	3
		Objective play	5
		Role-play	3
Game 5	CBeebies story time	Creative play	3
		Communication play	2
		Exploratory play	6
		Objective play	5
Game 6	Squiggle	Creative play	4
		Communication play	2
		Exploratory play	6
		Imaginative play	1
		Mastery play	2
		Objective play	6
Game 7	CBeebies play time	Symbolic play	2
		Rough and tumble play	1
		Socio-dramatic play	1
		Social play	1
		Creative play	6
		Communication play	1
		Exploratory play	6
		Objective play	5
		Role-play	1
Game 8	Minecraft	Creative play	7
		Exploratory play	6
		Imaginative play	4
		Mastery play	2
		Objective play	7
Game 9	Peppa pig collection(Paint box)	Socio-dramatic play	3
		Social play	4
		Creative play	6
		Communication play	2
		Exploratory play	6
		Imaginative play	2
		Objective play	7

4.3.2.2 Selective Themes of DGBL and play activity

Data were analyzed for a variety of Hughes' (2002) plays. When the kids used the tablet, there were 16 types of plays in digital games, as mentioned and listed in the previous section for each type of play with a sample of the project. The trick of integrating traditional and classic games in the real world of children with the virtual world in applications is a good way, making these applications more attractive and interactive. For example, Lego games can be replaced in the real world to enter the virtual world of applications and encourage children to build houses or other objects in these digital virtual games.

On the other hand, the use of children's favorite TV characters such as Peppa pig and CBeebies increases children's attention to digital games and only attracts children to continue playing in these applications. Therefore, children develop their imagination and creativity by showing these games in cyberspace with their favorite characters. As participant (6)'s mother pointed out;

*"**Participant (6)** is interested in choosing programs that are related to television programs (such as Peppa pig)."*

These digital educational games also create a creative, objective, and pre-acquired space in the virtual world, such as playing "Minecraft "or a scientific adventure in "Toca Boca Nature". Sometimes children liked a particular part of the digital game, for example, participant (1)'s teacher who saw her young student dancing in a CBeebies part of the game and receiving participant (1) only loves the music of the program.

According to table 4.6 and figure 4.3 that illustrate an overview of the number of references for each code seen in the observations of promoting play activity in DGBL. These themes emerged through supporting data from the teacher, parents, and researcher observations. The

feedback of these applications provided by preschoolers has strengthened them in some of play activities (see table 4.6, figure 4.3).

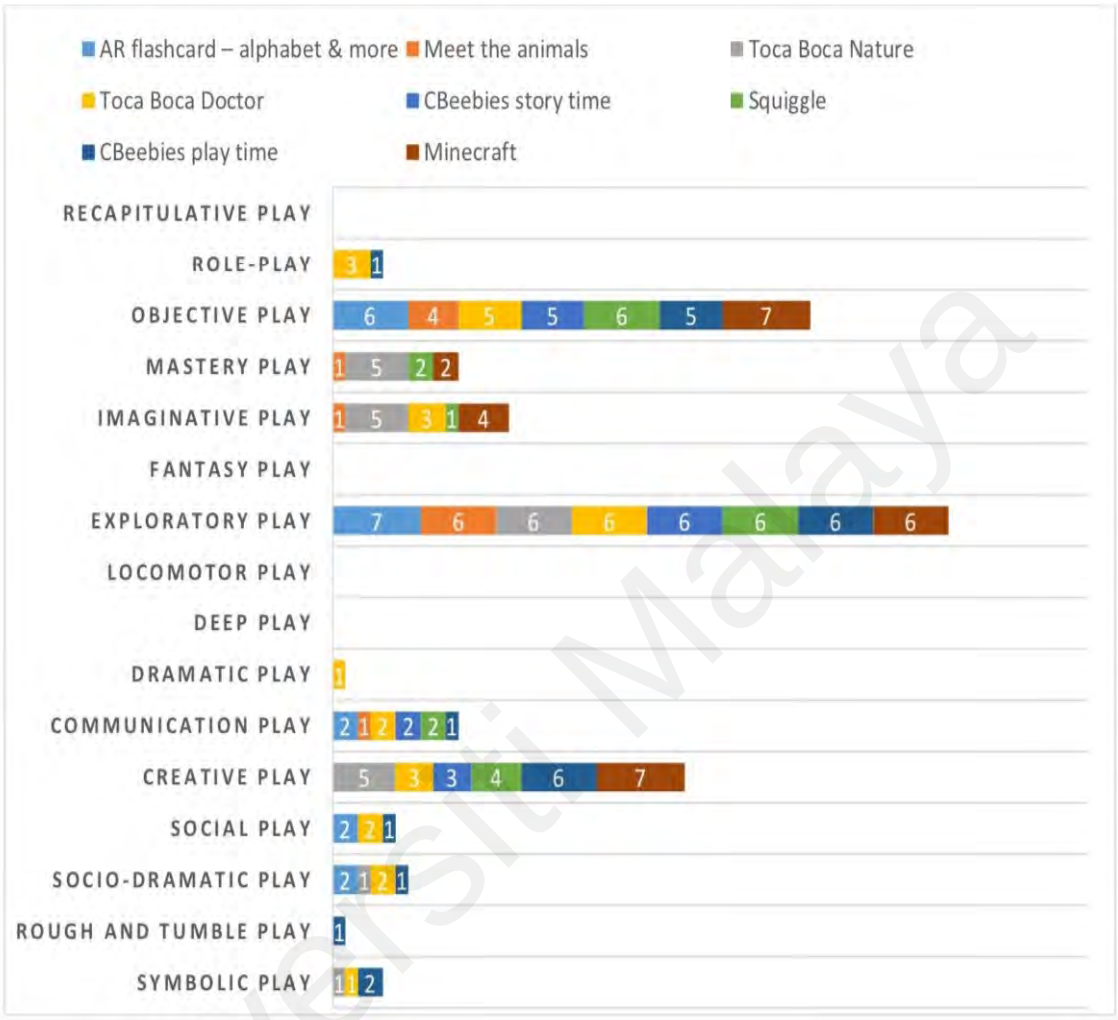

Figure 4.3: Observations of promoting play activity in DGBL at the preschool level

Consequently, according to the previous section obtained in this evaluation, the characteristics of various types of Hughes' (2002) taxonomy;

"Objective play",

"Exploratory play",

"Creative play", have been further developed in children (see table 4.3).

4.3.3 Section 3: Principles of DGBL and Pedagogy in applications

As mentioned in previous chapters, this thesis used principles of intervention DGBL based on creative-based learning (CBL) model (Bellotti, Berta et al., 2010) and the ARCS model for creative teaching (Keller, 2000) (see Chapter 2).

4.3.3.1 Open Coding, Axial Coding of DGBL and Pedagogy principles

Table 4.7 shows the general overviews of the themes through open coding, axial code, and data collection from the observation evidence of promoting principles of DGBL and Pedagogy in applications at the preschool level. These codes are based on data supported by evidence in this research (see table 4.7).

Table 4.7: Open Coding, Axial Coding, and Selective Themes of DGBL principles and pedagogy in applications at the preschool level.

Open Codes Of Principles of DGBL and Pedagogy in applications	**Axial Codes** From **Promoting Principles of DGBL and Pedagogy** in DGBL Offered	**Selective Themes from Promoting** Principles of DGBL and Pedagogy in **DGBL**
• Motivating to perform self-evaluation • Motivating to perform self-regulated learning	Inspiration	Inspiration
• Developing a personal learning strategy • Creating his/ her own learning environment while playing	Personification	Personification

Table 4.7: *(Continued.)* Open Coding, Axial Coding, and Selective Themes of DGBL principles and pedagogy in applications at the preschool level.

• Learning as a game • Using game thinking to solve problems	Gamification	
• Early attention to the game is increasingly • Engaging student with a query in game • Challenging learning goals.	Attention	Attention
• New knowledge aligns with prior knowledge in student.	Relevance	Relevance
• Feeling to reach learning goals. • Gaining self-motivation for reaching learning goals. • Gaining confidence for reaching learning goals.	Confidence	
• Learning outcomes have real values • Using learning outcomes for other contexts	Satisfaction	

Code of Inspiration:

As mentioned, based on the definition of this component the learner is motivated to perform self-evaluation and self-regulated learning.

Teacher **(T2)** regarding this component adapted in the project said an example:

*"…When the app asks **Participant (2)** to follow the letter C by swiping. The child is motivated to learn by swiping on the iPad screen. After dragging the letter C, the application shows him the cat as an example of the letter C. With this next step in the application, the child reaches the self-assessment of learning and realizes that he has learned the letter C in a regulatory way."*

Teacher **(T1)** regarding this component adapted in the project said an example:

*"… **Participant (3)** tries to put Minecraft pieces together. The combination of parts in the application confirms that he has done the right thing in creating the object. After placing the desired pieces with the voice of encouraging the application to do the right steps, he also finds the necessary motivation for self-evaluation and learning in the next step…"*

In this project, this component can also be exemplified in digital games in which:

*…. **Participant (7)** tries to learn to paint with a finger on a tablet screen. First, he tries to choose the color he wants. The child selects the color by touching the screen with his finger and then draws the desired color on the screen with one touch. These steps provide the child with the motivation to continue painting, and the child becomes aware of self-assessment and learning colors and drawing shapes…"*

*…. **Participant (6)** tries to listen to storytelling while playing with an app. The storyteller will not continue the story until the child presses the play and story*

button. With this movement, the child realizes the self-assessment that he can listen to the continuation of the story by placing his finger on the next button."

Code of Personification:

Based on the definition of this component; each learner develops a personal learning strategy, and creates his or her own learning environment while playing.

In this project, this component can also be exemplified in digital games in which:

".... For example, ***Participant (1)*** *who chooses the color he or she wants to draw the letters of the alphabet. He uses blue to draw the letter B. Then, seeing the ball for the letter B in blue, he shows with a smile of satisfaction that he is happy to use his personal strategy of using blue in the personalization of the alphabet learning environment."*

"…Participant (2) *tries to choose the clothes of the game character and tries to satisfy the environment and the character by choosing the color of the clothes and even its details. The child enters the game after preparing the character of the application with his desired clothes. In this way, the child personalizes the play environment with the designed character. Therefore, the child enhances his learning with the pleasure created by personalizing the game and connecting with the game."*

Teacher **(T1)** regarding this component adapted in the project said an example:

".... when ***Participant (7)*** *tries to learn the names of colors by drawing on a tablet screen. The child chooses each color with his finger. The app plays the color name aloud to him and the child learns the color name. Then the child draws a sun with his own color and turns it yellow and says that this color is called yellow and I drew with the yellow color of the sun. In this way, he changes the game environment by*

personalizing it in such a way that while enjoying the game. On the other hand, digital game helps his learning too."

"Another example is when ***Participant (4)*** *tries to make furniture with geometric shapes. The child chooses the shapes he wants, paints them, and then puts them together and says that what he has drawn is a table. By choosing shapes or colors and placing them next to each other, the child is reminded that he has used his personal strategy to create and enhance personal learning."*

Code of Gamification:

Learning as a game, using game thinking to solve problems is the definition of this component. In this project, this component can also be exemplified in digital games in which:

*".... **Participant (4)** first draws a word like Apple by drawing letters of the alphabet like the letter A, the digital play garden actually helps the child think about how and in what ways to draw the letter A from bottom to top and then vice versa."*

In another example, dragging numbers at the bottom of a number is a problem:

***"…Participant (5)** sees the number 2, he uses his mind to look for the corresponding shape. He looks for a shape that contains a handle of two numbers, and then by dragging the number to the shape and wrist to the number with the shape of the game, he reminds him that the child has taken the right path."*

Code of Attention:

Based on the definition of this component; In the beginning, student's early attention to the game is increasingly important. This can be achieved by engaging in a query which students have to give examples of problems related to their learning goals.

Teacher **(T2)** regarding this component adapted in the project said an example:

*"...This case was observed again and again in children because of the attractive atmosphere of the digital game, as soon as the game started and the sound of the game, attention was attracted by the game. To the extent that in some cases **participant (5)** did not ask questions, he drowned in the game and continued all the steps of the game. It is like drawing letters in which the child puts his finger in the path of his letter C and pays full attention to the game, and when the movement of path C is completed, a cat-like shape appears and the child happily says that it is a cat."*

Other teacher **(T1)** regarding this component adapted in the project said an example:

*"...Another example of this is the **Participant (1)** 's attention to drawing and coloring shapes when the application asks the child to paint the desired shape, for example a triangle in yellow. At this time, the child forms all his senses to find the color yellow and draw with his finger. Then the app encourages him and the child is happy. This child's reaction shows that the application has been useful and effective in engaging the child's senses in order for him to learn."*

Some adaptation of this component's examples has been seen in the recorded video:

*"In another example, when the app shows the child different animals in alphabetical order, **Participant (7)** sees the initials of each animal by placing a finger on each animal. Like when he touches the shape of a dog. The dog turns and the letter D of the alphabet appears. This strategy draws the child's full attention to learning."*

*"Another example is the use of colors in painting. **Participant (3)** is very interested in painting. By choosing different colors with his finger, he paints anything he wants on the screen. This drawing and painting with colors attracts the child's attention."*

Code of Relevance:

Students' new knowledge aligns with their prior knowledge is the definition of this component. In this project, this component can also be exemplified in digital games. Teacher **(T2)** regarding this component adapted in the project said:

> *"…. this component has been seen many times in digital app games. For example, when **participant (4)** learns the letters of the alphabet, followed by each letter, the beginning is the name of an object, animal, or object familiar to the child. For example, a child who has learned the letter C of the alphabet. Thus, he immediately knows the connection of this learning in the word of Cat. He knows that C is the alphabet letter of the beginning of the word cat."*

In another example teacher **(T1) said:**

> *"…. there is a color training that uses a drawing example in **participant (2)** application to learn where each color is used in its environment. For example, when the application shows the painted shape of a tree to the child and then it is the child's turn to paint the tree."*

Some adaptation of this component's examples has been seen in the recorded video:

> *"…**Participant (3)** learns through communication and bridges through prior knowledge that the trunk of the tree and its leaves begin to color the tree. The child explores their surroundings by learning basic shapes such as circles, triangles, squares or rectangles. The connection of these shapes can be easily touched in the environment around the child. When a child draws the sun in a yellow circle. This indicates the creation of a bridge between the new knowledge and the old knowledge of the child of forms."*

*"...In another example, when **participant (7)** makes a machine out of Minecraft parts, prior knowledge helps in the child's mind. This previous knowledge reminds the child that the four-wheeled car has a circular shape and has a rectangular body. So the child knows that he must first look for rectangular parts for the body and a circle for the car wheels."*

Code of Confidence:

Based on definition of this code, if students feel that they are reaching what they are learning goals, they will gain more self-motivation and confidence.

Teacher **(T2)** regarding this component adapted in the project said:

*".... In most cases, when **participant (4)** continues to play, it indicates that he has gained the motivation and confidence necessary to achieve the learning goals. These include the smile of the Ministry of Children or the child's curiosity to continue playing."*

In another example teacher **(T1) said:**

*"...**Participant (6)** was very interested in picking puzzles. In the end, he was very happy after picking the puzzle..."*

Code of Satisfaction:

Based on definition of this code, satisfaction occurs when the student understands that learning outcomes have real values which they can use in other contexts.

Teacher **(T2)** regarding this component adapted in the project said:

"...A smile of satisfaction, touching, screaming and shouting for joy when using the digital games application are some of the things that indicate the level of satisfaction created in children.

***Participant (1)** draws the letter U and then the shape of the umbrella appears and is happy that he was able to draw the letter U and satisfaction is seen in the child's face..."*

In another example teacher **(T1) said:**

*"**Participant (5)** knows how to paint a flower. He should turn the leaves green and paint the flower pink. The child shows the teacher that he has drawn a flower with a satisfying smile."*

Observations indicate that during the project, children continued to play with a good and positive feeling. Most of the kids were excited and happy while playing with the apps. These positive emotions and good feedback from digital games encouraged children to continue playing and led them to practice more in the areas of learning and fostering their creativity.

These games caused mental and physical pleasure to children and aroused their curiosity. Since the children during the game were curious about what would happen in the next stages of the game, discovering these traits through children in digital games provided them with an opportunity to continue and increase their level of learning. While using these games, children accompanied and helped their peers, and while socializing, their initiative and creativity also emerged.

What is obvious from the observations is that in the first stage, children are attracted to these digital games due to their great attractiveness and entertainment, and in the next stage, their learning rate also increases (Lanna and Oro, 2019). In this process, teachers were well able to guide in the path of children's learning and to develop and strengthen the children's level of

learning towards a specific goal, for example, when learning math, the English alphabet, and environmental sciences. Teachers played an important role in arousing children's curiosity to learn more in the digital space of games. Accompanying, educating, talking, and questioning teachers and connecting with children while playing with applications to speed up the learning process strengthened children's imagination in the digital space. Put differently, the learning process in children increased their level of experience, fostering computational thinking in order to analyze, combine, and evaluate the information obtained in the virtual space of applications.

On the other hand, the level of children's participation in selected digital games, depending on the nature of these games in terms of educational activities was completely different. In this study, how teachers guide children varies depending on students' individual preferences for creating digital content in creative thinking content activities. For example, in activities where children need instructions on how to build, the teacher helps them. In a game, the teacher asked the children to place three shapes of square, triangle, and circle in the empty space of these shapes in the application. Sometimes, the digital game itself provides children with instructions on how to build in the digital space. A good example includes the Lego game in the DGBL space.

Sometimes neither the teacher nor the game provides detailed instructions on how to proceed or build in the play area, and the child must use his/her imagination and creativity to come up with a new idea. For example, the teacher only asks the children to draw the sun in the digital space. These children, using their previous knowledge, use their imagination to get the shape of a yellow circle instead of the sun. Observations show that these applications encourage children to solve problems through active participation and the use of imagination. Inspired by play challenges, the child draws his/her own strategies to solve the challenge in mind, which strengthens the imagination, increases experience and knowledge, and creates new skills in children's minds. For example, one of the teachers said;

"Within playing digital educational games by kids, the child must recognize the behavior of the character to control the new and advanced world in the digital game space in order to rescue the character of the game in different game conditions and learn new skills."

Teachers need to innovate to use the digital space of applications to guide children's learning. Teachers play an active and leading role in the path of DGBL educational games when accompanying children in the use of applications. Observations suggest that teachers can be more flexible in their methods. Consequently, teachers are more easily adapted to the conditions and spaces of digital games and can improve the mental development of children. This thesis emphasizes on cultivating the components of creativity and its impact on the level of learning, believing that theoretical approaches and practical solutions are among the most popular trends in creativity-based education.

Table 4.8 reviews the number of references for each code perceived in the observations of promoting principles of DGBL and Pedagogy in applications at the preschool level. The amount of references for each code (each case study) seen in the observations. So, the number of references indicate how many case study (based on the categories of codes) exhibited such behavior during observation. The themes generated by data supported by observations of teachers, parents, and researchers (see table 4.8).

Table 4.8: Observations of promoting of DGBL and pedagogy principles in applications at the preschool level

Games Number	Name of DGBL applications	Observation Evidence of Promoting **Principles of DGBL and Pedagogy** in applications	Number of References (Case study)
Game 1	AR flashcard – alphabet & more	Inspiration	5
		Personification	5
		Gamification	2
		Attention	7
		Relevance	5
		Confidence	3
		Satisfaction	3
Game 2	Meet the animals	Inspiration	6
		Personification	5
		Gamification	2
		Attention	7
		Relevance	6
		Confidence	2
		Satisfaction	2
Game 3	Toca Boca Nature	Inspiration	7
		Personification	7
		Gamification	2
		Attention	6
		Relevance	6
		Confidence	4
		Satisfaction	4
Game 4	Toca Boca Doctor	Inspiration	7
		Personification	7
		Gamification	3
		Attention	7
		Relevance	6
		Confidence	3
		Satisfaction	2
Game 5	CBeebies story time	Inspiration	6
		Personification	7
		Gamification	2
		Attention	6
		Relevance	6
		Confidence	3
		Satisfaction	2
Game 6	Squiggle	Inspiration	7
		Personification	7
		Gamification	2
		Attention	5
		Relevance	5
		Confidence	3
		Satisfaction	2

Table 4.8: ***(Continued.)*** **Observations of promoting of DGBL and pedagogy principles in applications at the preschool level**

Game 7	CBeebies play time	Inspiration	6
		Personification	7
		Gamification	2
		Attention	5
		Relevance	5
		Confidence	2
		Satisfaction	2
Game 8	Minecraft	Inspiration	7
		Personification	7
		Gamification	3
		Attention	6
		Relevance	6
		Confidence	4
		Satisfaction	5
Game 9	Peppa pig collection(Paint box)	Inspiration	7
		Personification	7
		Gamification	3
		Attention	6
		Relevance	6
		Confidence	2
		Satisfaction	2

4.3.3.2 Selective Themes of principles of DGBL and pedagogy

As noted previously, this thesis used principles of intervention DGBL based on creative-based learning (CBL) model (Bellotti, Berta et al., 2010) and the ARCS model for creative teaching (Keller, 2000). Hence, the case study presented in this study describes creativity-based learning, which includes two principles: Creative teaching and creative learning. Using these principles can be a creative approach based on education and be effective in strengthening children's learning while strengthening creativity.

Therefore, table 4.8 and figure 4.4 illustrate an overview of the number of references for each code seen in the observations of promoting principles of DGBL and Pedagogy in applications at the preschool level. These themes emerged through supporting data from the

teacher, parents, and researcher observations. The feedback shows the themes of “Inspiration” and “Personification” are more prominent in creative learning based on DGBL principles. Also, "Attention" and "Relevance" are more outstanding in creative teaching principles (see table 4.8 & figure 4.4).

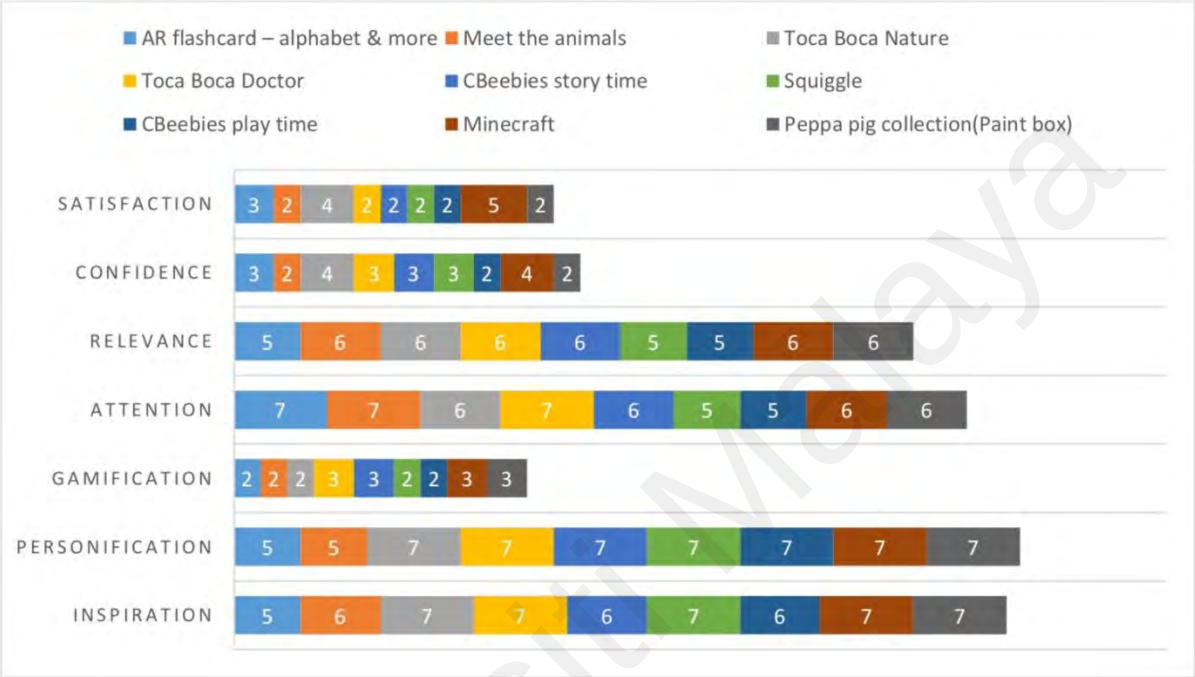

Figure 4.4: Observations of promoting of DGBL and pedagogy principles in applications at the preschool level

4.3.4 Section 4: Game Difficulty

The use of simple sounds and images in the settings of the application entertains the child and prevents confusion and boredom of children. It should be noted that the display screen for children should not be too crowded and complex to use. The use of children's popular characters, simple symbolic shapes, cheerful colors, simple signs and gestures, music, and special sounds can motivate children to play and continue and stimulate their response. Therefore, by using the aforementioned elements, it is possible to create attractiveness for the children, improve their creativity, and ultimately increase their learning.

Code of Swipe the screen:

Some of this code's examples have been seen in the recorded video:

*"**Participant (5)** uses his finger to go to the next slide to continue a story in "Storytelling". Elsewhere, they use "Swipe the Screen" to move the pieces to the full shape to create the child's puzzle…To see the animals, **participant (4)** also used his index finger to move the animal photo slides in the child application…. In another example, **participant (2)** used "swipe the screen" to see geometric shapes and learn their names so he could see the next shape."*

Code of Trace shapes with finger:

Some of this code's examples have been seen in the recorded video:

*"…to write the letters of the alphabet or numbers, **participant (1)** must type the shape of the letters with the finger with the option "Trace shapes with finger" to be able to prove to the application that he has learned to write letters and numbers…Drawing on a tablet is another option for using T. … **Participant (2)** trying to paint a tree with his finger provided by a colorless app…**Participant (4)** guides the game character with his finger on the path to victory."*

Code of Volume:

Some of this code's examples have been seen in the recorded video:

*"…The voice of the speaker in "storytelling" that made **Participant (2), participant (3) and participant (4) listen** to the story."*

*""Volume" was once an effective music. **Participant (4), participant (7) and participant (3)** were happy playing the musical notes and clapping."*

*"At other times, when **participant (3)** was solving the problem correctly and the voice was not loud, it made the child happy and motivated him to continue playing."*

*"The sound of repeating the letters of the alphabet and the names of the animals stimulated the **Participant (5), participant (6) and participant (3) t**o repeat afterwards."*

Code of Drag item:

Some of this code's examples have been seen in the recorded video:

*"**Participant (5)** used the "Drag item" option with his finger to send the numbers to the correct category. For example, a child who turns the number 3 into a "Drag item" triangle…. **Participant (1)** was drawing animals and objects alphabetically related to them. For example, a child who draws the letter C to the shape of a cat and uses the "Drag item" option."*

Or in the other case,

*"**Participant (4)**, after drawing the letter T, pulls it towards the tree using the "Drag item" option."*

In another example,

*"**Participant (6)** was offered a color application and asked to use the "Drag item" to change the color of the desired shape, such as a triangle, to yellow."*

Thus, the findings suggest that if programmers wish to design more effective DGBL programs for creativity and learning, they need to focus more on certain features of these games. For example, teachers should be able to change the curriculum and educational level in the game settings when using these digital educational games. Since preschoolers aged between 3 and 6

are in a period of playfulness and naughtiness, parents and teachers, having the ability to change the educational level of programs in the settings, can adjust the game to the level of interest and curiosity of children. Otherwise, the child may become bored or fail to solve the challenges due to hardness, and as a result, he/she may give up digital play. Therefore, teachers can strengthen and nurture children's creativity and learning by determining the level of challenge, activating, and deactivating it in settings.

Using too much text in the digital play menu, due to the child's inability to read the text, results in confusion, fatigue, and boredom in children. Therefore, using more symbolic forms can attract children to use the game by making them more attractive and interactive for children.

Using feedback and rewards such as coins or stars is another way to encourage and motivate children in digital games to continue playing. However, not all games need to be rewarded because the digital game itself and its attractive and colorful atmosphere provide the necessary motivation for children to continue playing.

Audio items in digital games should be amplified so that by listening to and repeating the desired symbol and guiding the child, the learning items have subconsciously resided in his/her mind. For example, in learning the English alphabet, after hearing each sound, the child points to the letters of the alphabet or vice versa. Moreover, apps should have audio questions which the child could think of and find answers to.

The results of this investigation showed that the frequently-used items by children are “Swipe the Screen”, “Trace shapes with fingers”, “Volume”, “Drag item” (see figure 4.5).

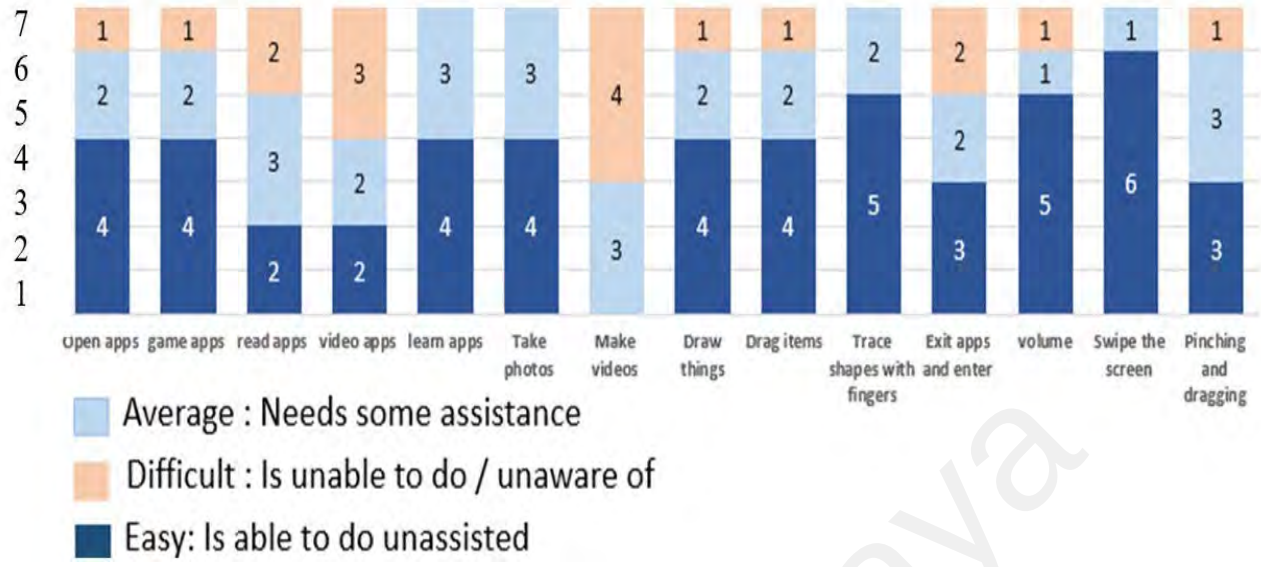

Figure 4.5: Game Difficulty

4.4 Summary of key findings

The performance of some of these digital games compared to other ones has further stimulated children's ability to develop creativity and learning. Among the selected educational digital games, more programs influenced the creativity and learning rate of children, which were designed for a specific preschool age group. These digital games had elements such as fantasy, imagination, curiosity, and exploration, and by creating challenges, they strengthened children's thinking skills such as creative thinking, problem-solving, critical, and computational thinking. Key findings of the identification themes from observations and interviews experiment one have been shown in the figure 4.6 (see figure 4.6).

These games have been able to establish faster and deeper interaction with young children aged 3 to 6 through the mentioned features. Therefore, these digital educational games can be said to have increased the level of creativity and learning in children due to their deep and fast interaction. Some teachers have stated that in some cases even these games have increased the

learning process of children in understanding some complex and time-consuming issues compared to traditional and non-digital teaching methods in the classroom.

Figure 4.6: Summary of key findings

These games also enhanced social skills as the child asked his/her friend or teacher for cooperation and play for each challenge. Children each have their own individual characteristics. For example, some children are calm, some others are lively and the rest are curious. These personal characteristics will also affect the extent to which children relate to digital play. However, the appeal of digital games due to its special cyberspace, cheerful colors, and creating a fun atmosphere for children, etc., attracts every child with any moral characteristics. This means that if digital games are designed to suit children's age, they may lead to faster interaction and the child will spend more time engaging with the game compared to traditional games in the real world. This more involvement of the child's, on the other hand, causes him/her to spend more time learning unconsciously; and eventually, digital educational games thus increase the amount of learning along with the play and increase creative skills in children (Behnamnia, Kamsin et al. 2020).

4.4.1 Discussion and Revisiting Proposed DGBL Model (Preschool level)

The results of analyzing the data collected from observations and interviews show that the level of creativity and learning in the use of selected games in children is different. Therefore, based on the key findings and the feedback collected from the findings in this thesis, the proposed initial model for increasing creativity and learning in preschool children was revisited. Key points of the identification themes were examined (see Figure 4.7).

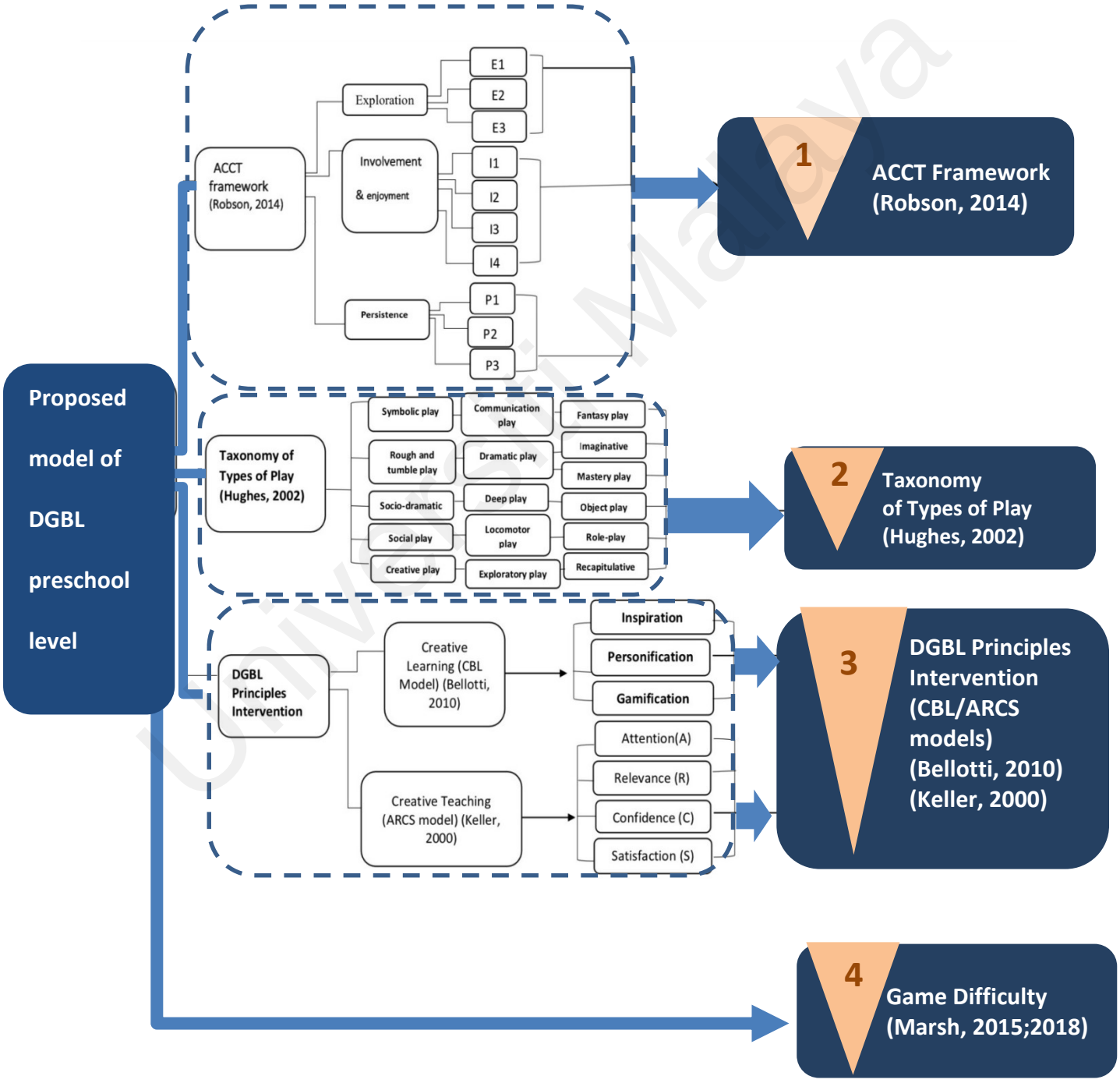

Figure 4.7: Proposed model of DGBL preschool level

This section describes how to review and improve the proposed model, and take actions in this thesis following feedback on the results. Furthermore, the main reasons and justifications resulting from this chapter are explained for each theme (see Figure 4.7).

According to the ACCT framework (Robson 2014) used in this study, the three most significant and obvious parts of components are “Exploration and engagement” topics showing that it has played a greater role than other themes and children's development in creativity and learning;

- E1: Exploring
- E2: Engaging in new activity
- E3: Knowing what you want to do

The main reasons for and justifications why these components fostered creativity and learning in young children are listed below:

1. The children were more interested in exploring, tending to discover a challenge and an activity to understand the rhythm of the game.

2. DGBL application stimulates the children's imagination and curiosity. In the next step, children try to identify the new knowledge presented in the games using their previous knowledge and try to present a new hypothesis or idea. This shows the children's inclination to creative and critical thinking and intellectual flexibility to the originality of divergent thinking.

3. Applications in which designers incorporate issues such as problem-solving, exploring, critical thinking encourage children to ask more questions, explore, or solve problems. These apps help children to further improve their creativity and learning.

4. These apps encourage children to ask teachers, parents, or peers to accompany, play, and sometimes even get help. It also subconsciously affects children's social skills and social communication after stimulating their activities.

In the DGBL apps and the types of creative activities section, the findings show that creative activities fostering creativity and learning among young children include the following:

- Drawing
- Painting
- Constructing
- Storytelling
- Music

The main reasons for and justification of why these components fostered creativity and learning among young children are listed below:

1. Most of the children's creative activities have been observed in digital games, which had topics or sections such as storytelling, interactive and visual books, painting, and coloring. This shows the profound psychological impact of these DGBLs on the psyche of children, in terms of play on the creative mind and thought process of children in the subject of learning. In this way, children become interested in writing the letters of the alphabet using these digital games and practice more.

2. Some applications such as Lego and Minecraft cause a significant increase in creativity (especially in constructing) in children.

3. From the world of art, music also plays an important role in the world of children. Listening to music made by the children themselves is enjoyable for children and opens a new world of art to them.

4. Due to the attractiveness and interaction DGBLs have with children, it causes children to spend more time, which is also involved in fostering children's creativity.

5. Children have a deeper connection with their parents, teachers, and even their peers with these apps. Since children often asked their peers, parents, and teachers for help and guidance in doing applications, this has caused teachers and parents to be closer to the world of children.

The main characteristics of various types of Hughes' (2002) taxonomy fostering creativity and children's development in learning include the following;

- Objective play
- Exploratory play
- Creative play

The main reasons for and justification of why these types of play fostered creativity and learning among young children are listed below:

1. Integrating traditional and classic games in the real world of children with the virtual world in applications is a good way, making these applications more attractive and interactive.
2. Using children's favorite TV characters such as Peppa pig and CBeebies increases children's attention and develops their imagination and creativity by showing these games in cyberspace with their favorite characters.
3. These digital educational games also create a creative, objective, and pre-acquired space in the virtual world, such as playing "Minecraft "or a scientific adventure in "Toca Boca Nature".

Categories of the findings from the principles of DGBLs and pedagogy include two categories "creative teaching" and "creative learning". These results show that in the creative teaching category, the following principles of DGBLs and pedagogy have enhanced creativity and learning in young children:

- Attention
- Relevance

The main reasons for and justification of why these principles fostered creativity and learning at the preschool level are listed below:

1. Teachers played an important role in arousing children's curiosity to learn more in the digital space of games. Accompanying, educating, talking, and questioning teachers and connecting with children while playing with applications to speed up the learning process strengthened children's imagination in the digital space.

2. Teachers need to be innovative to use the digital space of applications to provide children's learning.

3. Teachers should be able to change the curriculum and educational level in the game settings when using these digital educational games.

4. Teachers can strengthen and nurture children's creativity and learning by determining the level of challenge, activating, and deactivating it in settings.

5. In this thesis teachers were better able to guide in the path of children's learning and to develop and strengthen their level of learning towards a specific goal, for example, when learning math, the English alphabet, and environmental sciences.

Findings from the next category are “creative learning” showed that the following principles of DGBLs and pedagogy have enhanced young children's creativity and learning:

- Inspiration
- Personification

The main reasons for the justification of why these principles were fostering more creativity and learning among young children are:

1. Observations indicate that during the project, children continued to play with a good and positive feeling. These positive emotions and good feedback from digital games encouraged children to continue playing, leading them to practice more in the areas of learning and fostering their creativity.

2. These games caused mental and physical pleasure to children, arousing their curiosity. Since the children during the game were curious about what would happen in the next stages of the game, discovering these traits through children in digital games provided them with an opportunity to continue and increase their level of learning.

3. The learning process in children increased their level of experience, fostering computational thinking in order to analyze, combine, and evaluate the information obtained in the virtual space of applications.

4. These applications encourage children to solve problems through active participation and the use of imagination. Inspired by play challenges, the child draws his/her own strategies to solve the challenge in mind, which strengthens the imagination, increases experience and knowledge, and creates new skills in children's minds.

Categories of the findings from the difficulty of using games showed that some cases that improved creativity and learning are:

- Swipe the Screen
- Volume
- Trace shape with fingers
- Drag item

The main reasons for the justification of why these principles were fostering more creativity and learning among young children are:

1. Audio items in digital games should be amplified so that by listening to and repeating the desired symbol and guiding the child, the learning items have subconsciously resided in his/her mind. For example, while learning the English alphabet, after hearing each sound, the child points to the letters of the alphabet or vice versa. Meanwhile, apps should have audio questions that the child could think of and find answers to.

2. The use of simple sounds and images in the settings of the application entertains the child, preventing confusion and boredom in children. 3. The display screen for children should not be too crowded and complex to use.

4. Using too much text in the digital play menu, due to the child's inability to read the text, causes confusion, fatigue, and boredom in the child.

5. The use of children's popular characters, simple symbolic shapes, cheerful colors, simple signs and gestures, music, and special sounds can motivate children to play and continue and stimulate their response.

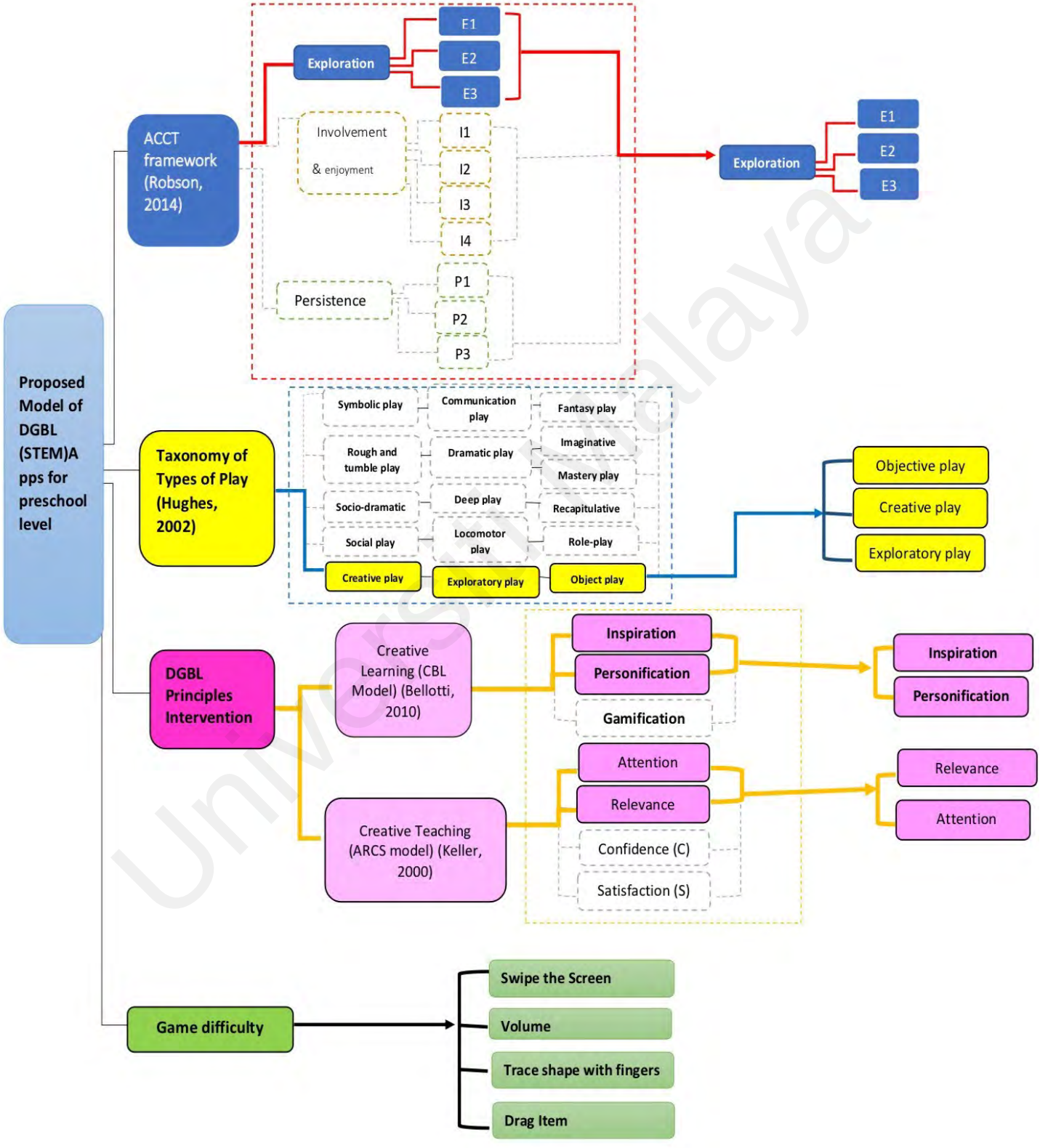

Figure 4.8: Revisiting proposed DGBL model (preschool level) with highlighted themes

The collected feedback from the key findings in this chapter was used to revise the initial model presented for the STEM (DGBL) to enhance creativity among preschoolers (in Chapter 5). In this thesis, key points were found and issues and suggestions were identified and examined. Therefore, revisions or modifications were made in the proposed model (see Figure 4.8).

4.5 Summary

This chapter reviewed the purpose and research questions for this thesis. Detailed descriptions of each participant are provided. In this chapter, the data analysis was explained step by step. The main themes emerged from the data and results by the initial code and then the decomposed code were finally organized. Code drop based on evidence and interviews of participants, parents, and teachers was repeatedly reviewed. The data that supports the viewing list of each code was described in detail. Therefore, the present chapter introduces the most effective features of creativity in selected digital games that were evaluated among young children. The connection of these components together with their impact on the level of learning has also been evaluated. This chapter also mentioned the important role of teachers in stimulating motivation and changing students' attitudes in order to enhance creativity and learning while playing in the digital environment.

CHAPTER 5: DATA ANALYSIS AND RESULTS OF EXPERIMENT (2)

5.1 Introduction

This chapter describes the findings gathered from the second experiment interviews. As discussed in the previous chapter, the proposed model was modified by identifying the valid features of creativity and playability to be fostered in children (from Chapter 4). Although the procedure of this experiment is similar to experiment (1) (see Chapter 4), in this chapter, to prove the proposed hypothesis based on the proposed model once again, a simple prototype of a STEM-based learning application was designed, implemented, and evaluated (see figure 5.1).

This chapter answers the following research questions:

Question 3: "How can a prototype of a game-based learning STEM app for preschoolers' level based on the proposed conceptual model of the DGBL app enhances creativity and achieve better academic skills for the preschool level?"

Question 4: "What are the effects of the proposed model of the game-based learning app on creativity and learning STEM among young children?"

As mentioned earlier, the procedure of this experiment is similar to the experiment (1) and the participants recruited in this experiment (2) consisted of students affiliated to Montessori preschool, too. The procedure used was a case study. Data collection, as well as data analysis, was provided by interviewing respondents among young children, consisting of four sections: Section 1: Observation of Principles of DGBL in the proposed model (components of pedagogy and STEM); Section 2: Observation of the type of creative thinking based on the proposed model; Section 3: Type of children's playing activities based on the proposed model; and Section 4: Game difficulty.

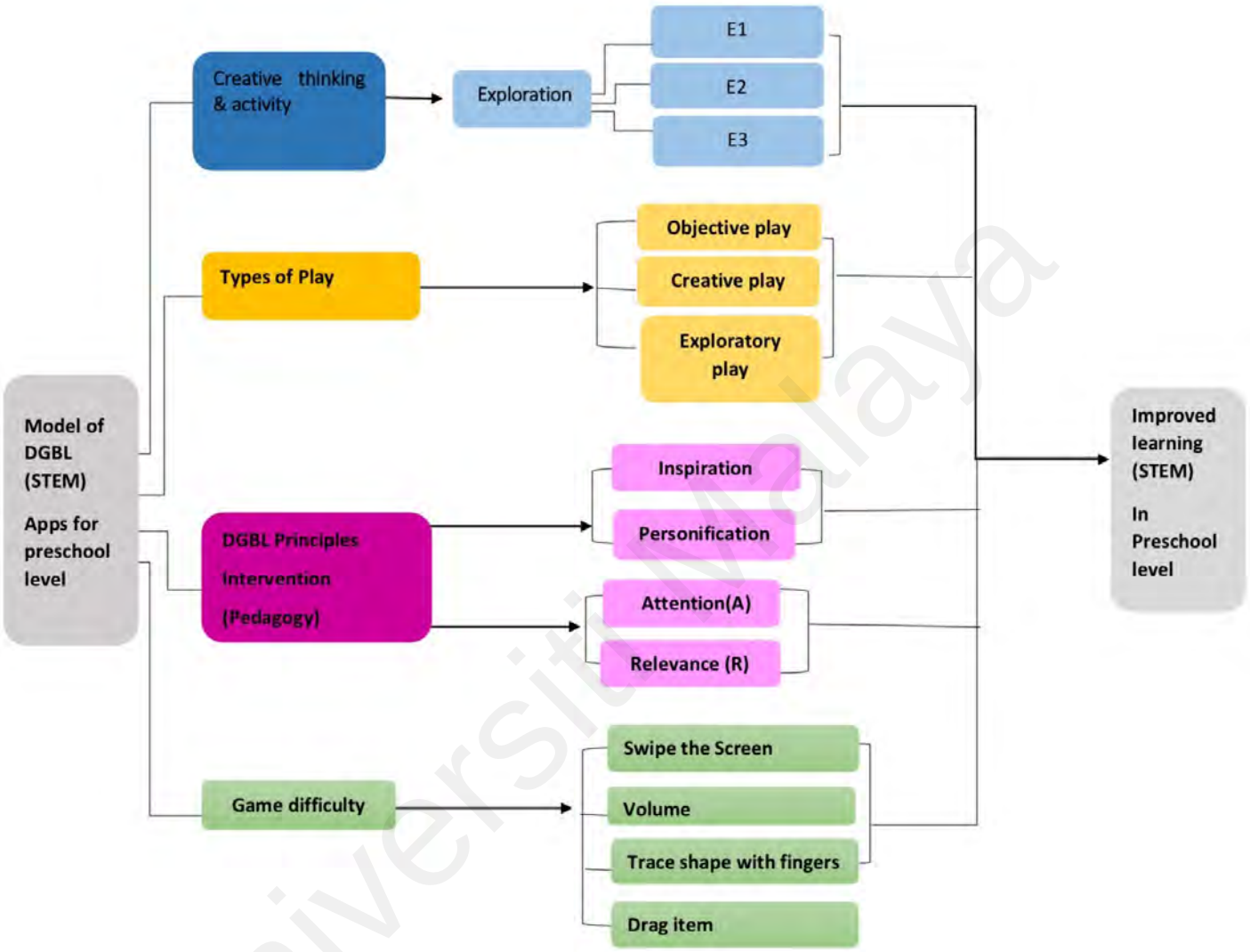

Figure 5.1: Proposed model of DGBL(STEM) apps fostering creativity to enhance learning at the preschool level

5.2 Overview of the findings

The findings are divided into four sections:

1. The first section describes the observation of creative teaching and learning with components of pedagogy and STEM-based on the proposed Model in the purposed prototype used by children in the interview. This section is focused on children's STEM learning include science, technology, engineering, and mathematics.

2. The second section examines the type of creative thinking children use based on the proposed Model. The results prove that the three features selected in the proposed model; E1: Exploring, E2: Engaging in new activity, and E3: Knowing what you want to do, increase the level of learning in technology, engineering, and science.

3. In section three, the type of children's playing activities based on the proposed model are discussed. These results show the features like "Exploratory Play" and "objective play" have the highest positive feedback.

4. In the last part, section 4 focuses on describing the difficulty of using the purposed prototype among young children.

5.3 Presentation of the Data and Results

5.3.1 Section 1: Effectiveness of Principles of DGBL in STEM Prototype

As mentioned in the intervention from the principle of DGBL in Chapter 2 includes two categories of principles; creative learning, and creative teaching (see Chapter 2). The use of these principles can be a creative approach based on education and effective in strengthening children's learning while fostering creativity.

Code of Personification in STEM Prototype:

Some of this code's examples have been seen in the recorded video:

"...In the prototype science section, ***participant (5)*** *memorized the path of each bird and the path of the crocodile. With a personal learning strategy, he moved the bird towards the door at the right time. He had planned to know that he would point his finger at the bird when the crocodile was on the other side of the screen. He knew that his quick action at the right time would save more birds from the crocodile attack and make them run away from the tree."*

In another example teacher **(T1) said:**

*"...****Participant (2)*** *learning from the prototype was fast. He remembered each animal by the name of the shape. For example, when the teacher asks him to draw a square, he touched the animal associated with the square. His strategy was to learn to remember each animal by the name of a shape and to repeat the name of that shape like a square."*

For example, one of the teachers **(T2)** said;

*"...****Participant (3)*** *in math used a self-identifying learning strategy to memorize numbers. For example, by remembering the shape of a hamburger, he also remembers the numbers associated with each shape, such as the number three, which was intended for the number of burgers. So every time he repeated the number three, he immediately pulled the number three towards the hamburger."*

In another example,

*"...****Participant (4)*** *'s other strategy was to count any number of shapes in the prototype. As soon as he heard the repeated number from the prototype, he began to count each shape. For example, when repeating prototype number 3, the child would start counting*

each option. After finding the hamburger, the child would touch it with his finger and make sure the choice was correct by cheering and confirming the prototype."

Code of Attention in STEM Prototype:

Some of this code's examples have been seen in the recorded video:

*"...**Participant (3)** enjoys drawing and the sound of a circle. The characters selected in the prototype had attracted the child's attention to the selection of shapes."*

In another example, it was observed in the science section.

*"...**Participant (2)** 's attention was drawn to the crocodile's rapid movement, and he showed his excitement at the crocodile's movement by touching, screaming, and cheering. For example, a child would start screaming as the crocodile approached his finger. His attention was drawn to the crocodile character. In such a way that the child selected the science section several times."*

Teacher **(T2)** stated that:

*"...I saw the feeling of satisfaction in smiling faces of the children while playing with the prototype. **Participant (3)** 's satisfaction with the game in the application caused the child to pay all his attention to the crocodile's movement."*

Teacher **(T1)** stated that:

*"...Children remember food well. For example, in the math section, **participant (4)** noticed the number of burgers knew exactly how many there were, and when the app repeated the number related to the number of burgers, the child's attention was quickly drawn to the burgers. He pointed the finger at the burgers."*

Code of Relevance in STEM Prototype:

The bridge of new children's knowledge with previous children's knowledge was well observed in the use of prototypes. Some of this code's examples have been seen in the recorded video:

*"..., **participant (4)** knew which number to drag to which group and group of shapes, given that he had learned numbers well in previous experiments in the tested samples."*

*"...**Participant (7)** had learned the number 3 well. In the category of shapes, he pointed to the number three."*

*"...**Participant (6)** had learned only the circle well from geometric shapes. When working with shapes in the prototype, the child would click on the animal associated with the circle, relying on his or her prior knowledge of the circle."*

Teacher **(T1)** stated that:

*"...In science, children knew the names of animals well in previous teachings. For example, **participant (3)** in the experiment knew that the bird could fly and could sit on a tree. His previous knowledge of prototype use helped him a lot. In this way, the child tried to protect the bird from being attacked by a crocodile while playing."*

In another example, teacher **(T2)** stated that:

*"**Participant (7)** knew that the animal crocodile was dangerous. She said the crocodile has sharp teeth and can bite anything. She had previous knowledge of crocodiles. She knew that in response to the crocodile, which was the center of attack and danger in the prototype, birds had to provide it."*

Code of Inspiration in STEM Prototype:

Some of this code's examples have been seen in the recorded video:

> *"...For example **Participant (7)** who tries to drag numbers to the proper shape of numbers in math. Hearing the sound of encouragement designed in the prototype makes the child notice the correct movement. Thus, in the next step in moving and using the prototype, he evaluates himself and learns self-regulation. Therefore, by knowing and repeating the number of numbers and seeing the number of shapes, the child remembers which number is related to which shape."*

In another example,

> *"... when **participant (5)** is asked by the teacher to draw a circle and a square in the prototype. The child raises his hand to the animal that draws the desired shape. He came to this assessment of himself and an arrangement that draws a circle. For example, in this prototype, a monkey draws a circle, and therefore, by repeating the name of the animal and the name of the shape, he dragged his finger towards the drawing circle."*

In another example, teacher **(T2)** stated that:

> *"...in the science section. When **participant (3)** becomes aware of the rhythm of the game. He finds out what path the crocodile takes to catch the birds. So he reaches self-adjustment and starts moving his fingers on the tablet screen so that he can fly the birds more easily towards the tree."*

In other examples, teacher **(T1)** stated that:

"...when the prototype repeats his name by drawing shapes. ***Participant (4)*** *gradually learns the name of each shape well by evaluating and self-regulating the repetition of the names of the shapes in the prototype."*

"The sound used to encourage in-app math helped ***participant (5)*** *achieve good self-assessment and self-regulation. So that every time you draw the correct number towards the correct number of shapes. Then he started clapping and cheering with joy."*

During the second experiment, the children were observed to feel positive and be excited when using digital technology in the prototype of STEM. Within using a digital game, the children were curious to use the game steps to reach the reward. They even collaborated and helped each other to build. The teachers also encouraged the children and looked for their learning level at any time. The children were experimenting, analyzing, combining, and evaluating the game during using the digital game-based learning provided. Looking more closely at the videos recorded between the children and the teachers, the researcher found that STEM games, due to the nature of these games in their dependence on children's real life, have increased their participation and increased their ideation. However, it should be noted that increasing creativity in children's ideation at each stage is also closely related to the teacher's encouragement and the attractiveness of digital game space design. Therefore, the nature of educational and learning activities in the design of digital games based on education can have a significant impact on the formation of divergent and critical thinking to find solutions to problems and create ideas in early childhood. All of this creates inner knowledge in scientific subjects, increasing children's view of the world around them. For example, a teacher **(T1)** said:

"In a part of the game the child has to tap the screen with his fingers to rescue a bird from an alligator's attack. The way the child's fingers move on the tablet screen at

the same time as his or her thinking about escaping the bird from the alligator makes the child investigate a way to solve the problem. Hence, the child's motor skills also increase. In addition, due to the emotional involvement of children, the digital space of the game evoked exciting and positive feedback for children."

Meanwhile, according to the observations, along with creative thinking, the child seeks to solve problems and physically move his/her fingers in the game while using the tablet, which causes children to learn new skills and techniques at the same time. Therefore, during using the DGBL prototype, while children thinking creatively, seek to solve problems, and move their fingers, which causes them to learn new skills and techniques physically in their minds during the game. Hence, when a child tries to solve problems while playing, at each stage, recalling previous knowledge can help the child climb to the next level. Hence, it is easier for a child to come up with ideas by connecting new knowledge with previous knowledge.

Teacher (**T1**) continued;

"Children's emotionality was also associated with emotional and positive feedback for children, this evoking the formation and occurrence of emotional conditions helps children's inner self-awareness."

However, children's attention in the game increases when the reward in the game, such as giving a coin or the sound of a recorded encouragement, is taken into account after each answer. For example, a teacher (**T2**) said;

"When one of the children was playing a section of math in DGBL (STEM prototype), the sound of the encouragement recorded during the correct answer made the child more excited and increased the child's sense of self-confidence. The child also began to clap his hands with excitement."

Hence, the results suggest that teachers should be flexible in their specific methods when teaching children during playing DGBL so that they can cultivate young students in the right direction at different times in the digital environment.

Table 5.1: Effectiveness of Principles of DGBL and Pedagogy in STEM Prototype

DGBL Principles	Purpose / Outcomes	STEM Codes	Number of references (Case study)
Inspiration	The learner is motivated to perform self-evaluation and self-regulated learning.	S	(3)
		T	(5)
		E	(4)
		M	(3)
Personification	Each learner develops a personal learning strategy, and creates his or her own learning environment while playing.	S	(3)
		T	(7)
		E	(6)
		M	(6)
Attention	In the beginning, student's early attention to the game is increasingly important. This can be achieved by engaging in a query which students have to give examples of problems related to their learning goals.	S	(5)
		T	(5)
		E	(6)
		M	(3)
Relevance	Students' new knowledge aligns with their prior knowledge.	S	(7)
		T	(6)
		E	(5)
		M	(5)

According to definitions of principles of DGBL (see Chapter 2), the results of observations show that the themes of "inspiration" in technology and "personification " in technology, engineering, and mathematics, are more prominent on the basis of the DGBL principles of creative learning and that "attention" in science, technology, and engineering, and "relevance"

in science and mathematics are more prominent in the principles of creative teaching. The amount of references for each code (each case study) seen in the observations. So, the number of references indicate how many case study (based on the categories of codes) exhibited such behavior during observation. (see table 5.1).

5.3.2 Section 2: Creative Thinking and Activity in STEM Prototype

Code of E1 in STEM Prototype

The tendency to detect in prototypes was observed in children in more cases. The use of simple icons in the prototype made it easy for the child to continue the curiosity about the game. Some of this code's examples have been seen in the recorded video:

For example,

> *"…. after entering the mathematics section,* ***participant (5)*** *was able to discover the relationship and classification of shapes and numbers. After understanding this connection, the child began to send the numbers to the groups."*

Another example was the discovery of prototype scheduling in children.

> *"…****Participant (1)*** *tried to understand the crocodile's scheduling rhythm. By understanding this rhythm, she was able to understand when to move the birds with her fingers towards the tree."*

In another example, teacher **(T1)** stated:

> *"… a tendency was discovered in* ***participant (2)*** *to touch animal icons to draw shapes. The shape of the circle was his favorite. He remembered the animal associated*

with the figure. In the same way, by touching and clicking on the desired animal, he could reach his favorite shape."

Code of E2 in STEM Prototype:

Some of this code's examples have been seen in the recorded video. An example of viewing the E2 code can be seen in Participant (2):

*"... His friend helped him with the typing beam in math. He instructed the other child**, participant (3),** to drag the number three into the appropriate shape category. The participation of two friends with a child's photo can lead the number three to the correct category."*

In another example,

*"... **participant (1)** memorized all animal-related shapes reminded a friend who participated in the experiment **participant (2)** that if he wanted to draw a circle, he had to click on the monkey."*

Another example was the group encouragement of children for science:

*"...Other children encouraged **participant (4)** to use the iPad so that the child could save the bird from the crocodile attack at the right time. Accurate timing of the baby's fingers allowed the bird to escape the crocodile attack and land on the tree at the right time. The children got excited and started cheering."*

Code of E3 in STEM Prototype:

Enjoying the discovery of different parts of the game is also one of the things that has been seen in the recorded video. For example,

> *"...**participant (3)** tried to click on the animals in the game with a satisfied smile. He was curious and wanted to know what would happen when he clicked on each animal."*

A sense of curiosity and enjoyment of play was also observed in younger children.

> *"..... **participant (6)** by clicking and touching an animal, observes that the animal begins to draw a circle, square, or triangle. The child was happy and screamed with joy."*

Another example of enjoying curiosity for the E3 code is another child. In the video, it was seen that:

> *".... **participant (4)** is excited about moving the numbers towards the category of shapes. He insisted on repeating the movement several times to put the correct number on the correct shape."*

Video observations demonstrated that using the STEM prototype has been able to improve children's learning as well as play and creativity. Observations and data collected by the researcher show that due to the curiosity and attractiveness of digital games for children during using of technology of iPad tablet, they spend more time playing and engaging with digital space, which in turn increases children's creativity and level of learning.

For this reason, the positive impact of three creativity factors (E1, E2, E3, obtained from Chapter 4) indicated an increase in learning in different STEM areas for children have

observed. However, themes such as E1 and E2 have impacted to increase more learning in children in "Engineering" and "Science".

As mentioned in Chapter 4, since the digital environment reduces the stress of the school environment for children, and as a result, they focus more on the digital game, subsequently increasing their learning. Paying attention to the attractiveness of cyberspace, on the other hand, causes the child to be involved in the game for a longer period of time, and this in itself leads to the subconscious effect and further learning of children.

Creating subconscious knowledge in children makes it easier for children to deal with challenges in life and find solutions to them by connecting with their previous and new inner knowledge. For example, in the simple prototype of STEM presented in this thesis, in the "Science" section, due to the escape of the birds from the crocodile's hands, there was more emotional excitement for children. Also, in the "Mathematics" section prototype, due to the voice of encouragement, it led to more interest in children's learning in mathematics. In the field of "Engineering", drawing shapes such as circle, triangle, etc., along with fostering creative activities, increased learning, and this indicated further strengthens the connection between creativity and engineering. For example, one of the teachers **(T1)** said:

> *"The repetition of the prototype game designed caused children to be more active in some activities, such as solving math problems and drawing shapes."*

Besides, evidence of enhanced social skills and relationships was found in children. For example, another teacher **(T2)** said;

> *" **Participant (3)** was very excited about playing crocodiles and invited her friends to help her get the bird out of the crocodile's hands. **Participant (3)** was a very quiet child. But while playing the prototype, he was excited."*

Therefore, this type of digital activities and games can be said to indirectly strengthen children's social skills. In other cases, teachers mentioned improving children's learning of saying the names such as triangles and circles, etc. when drawing these shapes in engineering.

For example, one of the teachers **(T1)** said:

*" **Participant (5)** often had trouble saying the names of the shapes and often made mistakes in saying their names, but after repeating the shapes with his finger on the iPad on the prototype, he was able to repeat the name of shapes with the broadcast sound".*

Table 5.2: Dimensions of Creative Thinking in STEM Prototype

Dimensions of Creative thinking		**Purpose /Output**	**Nvivo coding**	**STEM Codes**	**Number of references (Case study)**
Exploration	Exploring	Tending to discover the potential of a challenge, activity or substance	E1	S	(5)
				T	(4)
				E	(5)
				M	(3)
	Engaging in the new activity	Ready to get involved in an activity and coming up with an idea	E2	S	(6)
				T	(5)
				E	(4)
				M	(5)
	knowing what you want to do	Enjoyment of being curious when choosing a game	E3	S	(4)
				T	(5)
				E	(4)
				M	(4)

The using presence of fancy animal characters along with drawing shapes made it more exciting for children and made them more attractive and interactive in this part of the game. What is shown from the recorded videos is that children are mostly interested in "Exploring". Hence, as respect to table 5.2 shown, the results prove that the three features selected; E1, E2, and E3 increase the level of learning in technology, engineering, and science. Yet, there are little weaknesses in "E3" in mathematics. The amount of references for each code (each case study) seen in the observations. So, the number of references indicate how many case study (based on the categories of codes) exhibited such behavior during observation. (see table 5.2).

5.3.3 Section 3: Types of Play in STEM Prototype

As discussed in Chapter 4 Section 2: DGBL and play activity, from the types of playing based on the Hughes' (2002) classification, three types of play themes in the virtual space of digital games based on education strengthened children's creativity and learning; 1. Objective play, 2. Exploratory play, 3. Creative play.

Code of Objective Play in STEM Prototype:

The child's use of the sense of touch for digital games was also widely seen in the prototype. For example,

> *".... when **participant (2)** had to touch and click on the animals so that each animal could begin to draw its own shape. The child repeated "Objective Play" by touching each animal to draw each shape."*

In the other case,

*"... **participant (3)** was trying to figure out how to move the numbers with his fingers on the screen. The child's attempt to control the movement of numbers with his fingers in the math section refers to the repetition of the "objective play" code."*

In another example,

*"...**participant (6)** moves its fingers to be able to touch the bird. The bird flies by touching the child and escapes the crocodile. Excited, the child repeatedly touches the bird on the screen for fear of being attacked by the crocodile so that it can escape. This also refers to the frequent viewing of the "Objective play" code."*

Code of Exploratory Play in STEM Prototype:

Another type of play that frequently uses the "exploratory Play" in STEM Prototype. For example,

*"....in the case of **participant (7)**, she tried to search for a number with a classification group. So each time she sent each number out of curiosity to all four groups of shapes. At each correct move, when the number was matched with the appropriate handle of the shapes, the app's app sound confirmed that the move was correct."*

In the other case,

*".... when **participant (6)** tried to detect all kinds of shapes from animals in the prototype. For example, the child repeatedly touched each animal in the prototype while trying to detect shapes. He wanted to make sure what shape each animal created."*

In another case, in this experiment can mention the discovery of the type of bird movement by touching ***participant (6)*** differently in the science section in the prototype.

> *"...**participant (6)** tried to find a way to escape the bird from the crocodile attack by touching in different directions."*

Code of Creative play in STEM Prototype:

This case was seen many times in the science section of the prototype game.

For example, one of the teachers **(T1)** said:

> *".... **participant (7)** trying to use different routes for a bird to fly. I was able to see creativity in the child using creativity to create new solutions and a new way to escape the bird from the crocodile."*

Since the children were interested in searching and curious to discover the next stages of the prototype of STEM, breeding all kinds of "Exploratory play" was more common. On the other hand, a sample of "Objective play" showed that children were very interested in following the steps of the game to get rewards, and subsequently, they were interested in continuing the game and learning.

In the "Creative play" section (referring to the science games section in the prototype of STEM), for example, where participants looked for different creative solutions to escape the bird from the crocodile attack. As mentioned in the previous sections, fostering creativity for children happens alongside playing them, and the two, play and creativity, are inseparable.

Apart from these two factors, the inclusion of learning items can also encourage the child to learn subconsciously while having the attractiveness of play and divergent thinking. For instance, in the STEM prototype game "Engineering" section, children were very interested in touching the iPad on the shape of fantasy animals to draw different shapes, and by repeating

the names of geometric shapes, they showed their desire to draw the desired shape. One of the teachers said:

> *" **Participant (2)** did not know the names of geometric shapes, but after using this STEM prototype, he repeated the names of the shapes, showing his interest in drawing the desired shapes, which shows the child's connection with play and increasing his level of unconscious learning."*

Children over the age of four were more interested in solving math and science challenges in STEM prototype. At the same time, children under the age of four were excited about a part of the game such as the sound of music playing, encouragement, or the sound of animals. For example, one of the teachers said:

> *"The mathematic part of the STEM prototype was a little hard for **participant (7)**, but she's interested in the math section was due to the cheering sound for her friends' correct answers, which also excited her and made Lela start clapping and cheering with excitement."*

The results of this part in table 5.3 indicate that the highest strengths are in "Exploratory Play" for "Engineering" and "Math" as well as "Objective play" for "Engineering". The result shows that features like "Exploratory play" and "Objective play" have the highest positive feedback. The amount of references for each code (each case study) seen in the observations. So, the number of references indicate how many case study (based on the categories of codes) exhibited such behavior during observation (see table 5.3).

Table 5.3: Dimensions of Playing Types in STEM Prototype

Promoting features of playing	Purpose /Output	STEM Codes	Number of references (Case study)
Exploring play	Children play all their senses by searching for objects, spaces, and so on through the information available in the game.	S	(4)
		T	(5)
		E	(6)
		M	(5)
Object play	Child is ready to play with objects that involve the child's sense of touch and vision.	S	(4)
		T	(5)
		E	(6)
		M	(6)
Creative play	Child is ready to explore, develop ideas and things.	S	(4)
		T	(4)
		E	(4)
		M	(3)

5.3.4 Section 4: Game Difficulty in STEM Prototype

In this section, as in Chapter 4, the difficulty of using a prototype of STEM for children was assessed. This difficulty was divided into 3 categories according to Chapter 4: Difficult (is unable to do /unaware of), average (needs some assistance), easy (is able to do unassisted).

Code of Swipe the Screen in STEM Prototype:

Children used "Swipe the screen" many times to easily enter sections and other sections in the application.

For example,

"…. ***Participant (2)*** with "Swipe the Screen" was able to go from math to science."

*"...**Participant (3)*** uses "Swipe the screen" to bring the numbers to the shape categorization section."

In another example,

*"...**Participant (5)** tried to bring a bird to a tree by moving his finger up and down on the iPad touch screen in the prototype. He also used the "Swipe the Screen" option."*

Code of Trace Shape with Finger in STEM Prototype:

For example, in drawing the shapes of the child,

*"... **Participant (2)** used his finger to make a circular path with the movement of the animal "Trace Shape with". After using "Trace Shape with", the child began to repeat the name of the circle. After each drawing and repetition of the shape name, the child learned the name of the circle shape."*

Another example, in the math section,

***"…Participant (5)** was able to move the number 3 to the "hamburger" category by classifying shapes to "Trace Shape with"."*

*".... Using "Trace Shape with", **Participant (4)** was able to guide the number 5 to several categories of correct shapes."*

According to the researcher's observation and teachers, the sound of encouragement, the sound of animals, the repetition of numbers and repetitive shapes, attractive colors along with music could be factors that attracted the child to the prototype of STEM, stimulated their creativity, and subsequently raised the level of learning of young participants. On the other

hand, teachers had the ability to make changes to the game setup system from hard to easy such as reducing the number of birds to one to cross the crocodile front (in the science section of STEM prototype). Another example is using simpler and beginner numbers for younger children aged under 4 (in the math section of STEM prototype), resulting in increasing children's ability to learn different STEM sections.

In addition, the use of rewards and the incentive voice in the STEM prototype in the math section encouraged children to be motivated to solve math problems and to be motivated to continue playing. Repeating the name voice of geometric shapes after drawing them in the engineering part has increased children's learning of the names of shapes and strengthening motor skills in children's fingers. The results of this research in figure 5.2 indicated that the highest strengths can be seen in "swipe the screen", "trace shapes with fingers", "volume", "drag the item". However, as shown in the diagram, features like; "Pinching and Dragging", "Exit apps and Enter", have poor feedback (see figure 5.2).

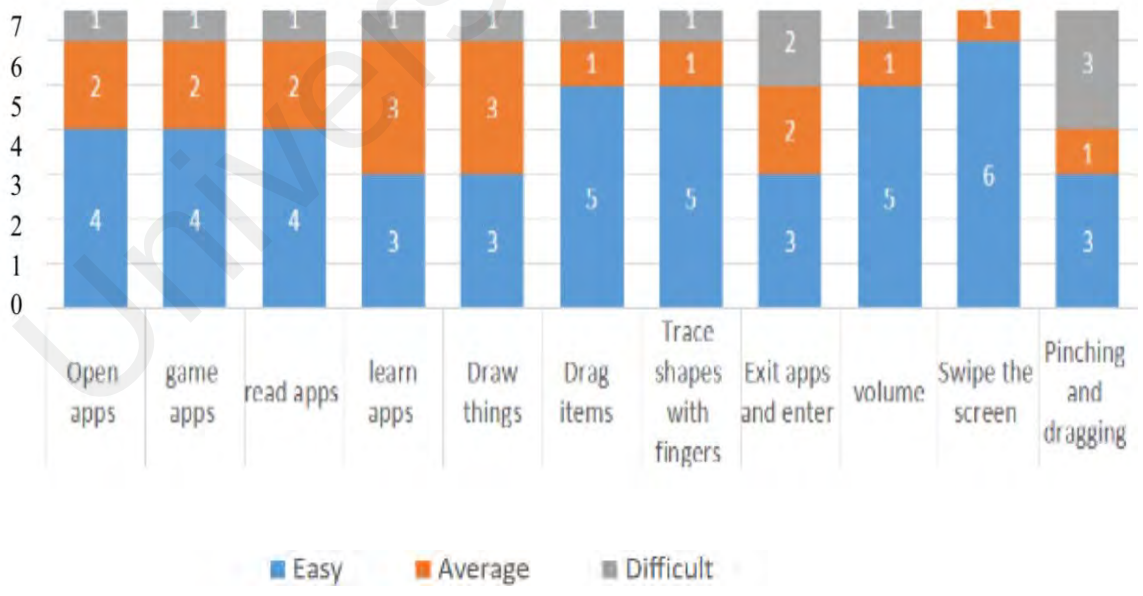

Figure 5.2: Game Difficulty

5.4 Summary

This chapter presents the results of the second experiment to evaluate the proposed DGBL model based on STEM, which includes four sections: 1. DGBL principles and training in DGBL prototype based on STEM and the proposed model; 2. Creative thinking in the DGBL prototype based on STEM and the proposed model; 3. Types of games based on the proposed model; and 4. Game Difficulty. In addition, the important findings and summaries of Experiment 2 were highlighted and explained. The list of important types of play was upgraded. The components of the creativity of the targeted in the proposed model of STEM-based learning were highlighted to enhance learning. The reasons for the game's limitations, creativity, and learning in the prototype of STEM were described. The results show that this study enhances creative thinking and learning activities in play-based learning programs among preschool children. The potential of using the components of creativity in educational games causes the child to experience meaningful play in the digital space.

This means that children in the early stages of life learn to enjoy life while thinking about things and to actively explore and listen to their surroundings. Therefore, it can be said that following theories of constructivism, along with creativity, in the digital learning environment allows the learner to use his creative thinking and implementation as a guide for his curriculum. A list of topics identified this season shows how DGBL prototypes based on STEM learning can influence the creativity and learning of preschool children.

In the next section, Chapter 6 provides an overview of data analysis and interpretation, discussions of the implications of the findings, recommendations for action, recommendations for future research, discussions of experiences in the research process, and a summary of statements.

CHAPTER 6: CONCLUSION AND FUTURE STUDIES

The purpose of this chapter is to present an overall discussion study, the conclusions, and the future implications of the study. This thesis presented the key findings of the literature discussed in Chapter 2 and additional supporting literature through the lens of components of creativity, types of play, and principles of DGBL in the conceptual framework that guided this study. This thesis concludes Chapter 6 with recommendations for future research, practice, and policy.

6.1 Summary of the Results

The main purpose of this study is to investigate whether digital application technology in DGBL when using tablets and smartphones, can improve creativity skills and learning in preschool children aged between 3 and 6. The qualitative study was guided by four main research objectives:

RO 1: To investigate and identify features for fostering creative thinking through DGBL apps.

RO 2: To develop a model that integrates content, behavioral, and applying components of creativity, roles, and relationship with learning in DGBL apps for preschool level.

RO 3: To design and implement a prototype of a game-based learning STEM app for preschooler level based on the proposed model of DGBL apps.

RO 4: To evaluate the proposed model of game-based learning and creativity apps.

In the present study, during the use of digital educational games by young children, the process of children's creative thinking and the relationship between the components of creativity and learning for children were examined. In this study, in two experiments that the procedure was the case study. As mentioned earlier, in the first experiment, the researcher

evaluated a number of applications existing on the market among seven children aged 3 to 6 years. The aim of this evaluation was to distinguish the effective features of creativity, types of play, learning and principles of DGBL, and game difficulty in the mentioned applications through observation and interviews. As previously mentioned, two teachers and seven parents of the children were also asked to cooperate in the evaluation at a pre-school in Montessori (Malaysia). The whole analysis of the data set was to examine how fostering creativity and play can affect children's learning.

Findings indicate that digital educational games have the capability to stimulate the imagination and develop creative skills, critical thinking, deep understanding of knowledge, and deep learning. Evaluations also show that digital educational games increase children's inner excitement and motivate them to continue learning. These games also develop children's social skills by creating opportunities for them to participate in creative activities. This experience provides a clear perspective on the use of DGBL digital games for scientists and researchers, teachers and psychologists, game designers, and parents.

Children each have their own individual characteristics, for example, some children are calm, some others are lively, the rest are curious. These personal characteristics will also affect how they relate to digital games. However, the appeal of digital games due to the special cyberspace, cheerful colors, and creating a fun atmosphere for children, attracts any child with any moral characteristics. This means that once digital games are designed for children's age, it may lead to faster interaction in that children will spend more time playing games than traditional games in the real world.

On the other hand, more involvement of the child causes him/her to spend more time learning unconsciously, and ultimately digital educational games thus increase the amount of learning along with the play and increase creative skills in children.

According to the data obtained from interviews with teachers and parents, as well as observations of children while playing with digital educational games, the appropriateness of designing digital educational games for children's age and their intellectual and emotional space increases the level of creativity and learning. In this way, these DGBL games can establish a deep connection with children. In other words, digital games increase children's skills in problem solving and creativity by increasing children's skills in play and creativity and have a positive effect on the learning process and thus increase the speed of the learning process.

Furthermore, the results of the data indicate that DGBL games have a suitable background for teaching topics such as science, technology, engineering, and mathematics (STEM). These games, due to their ability and special features to present imaginative and complex space in digital space, provide the ability to convey abstract and complex concepts of many sciences in a simple way for children. Therefore, it can be said that from a specialized point of view, this feature is only specific to these digital games and this new technology.

Therefore, to summarize of findings and achievements have been shown in table 6.1(see table 6.1).

Table 6.1: Summarize of findings and achievements

N	Objective (s)	Research Question (s)	Achievements
1	To investigate and identify features for fostering creative thinking through DGBL apps.	What are the limitations of existing models and frameworks of DGBL for fostering creative thinking approach preschoolers to better learning STEM?	Resources Used - thesis, e-book, journals, and conference proceedings: • **Historical data** • **Pilot study** • **Experience survey** • **Case study**
2	To develop a model that integrates content, behavioral, and applying components of creativity, roles, and relationship with learning in DGBL apps for preschool level.	How to develop a model of game-based learning that can enhance creativity among preschoolers to better learning STEM?	**Identification of support features DGBL for fostering creativity and learning:** • **CT**: E1/ E2/ E3 • **Creative activity:** Drawing/ Painting/ Constructing/ Storytelling/ Music • **Play:** Objective play/ Exploratory play/ Creative play • **Pedagogy;** Creative Learning: Inspiration/ Personification, Creative Teaching: Attention/ Relevance • **Game Difficulty**: Swipe the Screen/ Trace shapes with fingers/ Volume/ Drag item
3	To design and implement a prototype of a game-based learning STEM app for preschooler level based on the proposed model of DGBL apps.	How can a prototype of a game-based learning STEM app for preschoolers' level based on the proposed conceptual model of the DGBL app enhance creativity and achieve better academic skills for the preschool level?	. **A unified model of STEM - DGBL apps to enhance creativity among preschoolers** . **A prototype of a DGBL-STEM app for preschooler level based on the proposed model**

Table 6.1: ***(Continued.)*** **Summarize of findings and achievements**

4	To evaluate the proposed model of game-based learning and creativity apps.	What are the effects of the proposed model of the game-based learning app on creativity and learning STEM among young children?	• **Participation has been increased among young children.** • **Creative thinking has been stimulated among young children.** • **Self-confidence has been enhanced among young children.** • **Critical thinking and exploration have been encouraged by young children.** • **Children learned how to share, negotiate, and solve problems with each other.** • **"Pinching and Dragging", "Exit apps and Enter", have done poor feedback.**

6.2 Interpretations and Conclusions of finding

6.2.1 Results: Research Objective 1

The first research objective was: To investigate and identify features for fostering creative thinking through DGBL apps.

In order to design and develop a model that integrates the content by applying components of creativity, roles, and relationship with learning in DGBL apps for the preschool level, investigating and identify features for fostering creative thinking through DGBL apps was necessary. Hence, the components of creativity and its relationship at the level of learning in

children under 6 when using a number of digital games based on the mentioned educational principles were examined. As mentioned earlier, in this thesis identified categories of games are based on Hughes' (2002) category and the creativity component are on the basis of Robson's (2014) ACCT framework (Hughes, 2002; Robson, 2014).

The analysis of data, sets of observations, and interviews of children indicate that the level of creativity and learning in the use of selected games in children is varied. Obviously, the performance of a number of selected digital games that have stimulated children's ability to develop creativity and learning was more than other games.

Among the digital educational games selected, the most influential applications on children's creativity and learning rate were defined and designed for this specific age group (preschool level). These digital games had elements such as fantasy, imagination, curiosity, and exploration and challenged children's intellectual skills such as creative thinking, problem-solving, critical thinking, and computational thinking. These games also enhanced social skills as the child sought cooperation and play with a friend or teacher to solve any challenge during play. The special design of these digital games was based on teaching how to design a happy and gentle digital space for young children without creating tension, stress, and struggle.

Although children's individual characteristics affect their interaction with programs, the attractiveness of space and digital game characters is a major factor in attracting children. For example, the use of cheerful colors and fantasy characters with childish voices were other distinguishing features of these digital games in attracting children.

On the other hand, some games focused on the theory of structuralism by focusing on creative and divergent thinking in children led to the development of the child in problem-solving skills and creative construction. One of them is Minecraft games. Through the above-mentioned features, these games were able to establish a faster and deeper interaction with

young children aged 3 to 6 years. Therefore, due to deep and fast interaction, these digital educational games can be said to increase the level of creativity and learning in children.

Some teachers even stated that these games increased children's learning process to understand some complex and time-consuming issues compared to traditional and non-digital teaching methods in the classroom. In some cases, parents' teachers have pointed out that digital games not only limit children's play and creativity but also reduce children's learning. With a closer look at these games, in these digital games, less attention has been paid to elements such as problem-solving and creating challenges in game design, and elements such as using children's imagination and curiosity have been ignored.

As mentioned earlier, DGBLs have potential capabilities in STEM topics (Science, Mathematics, Engineering, and Technology). These digital STEM game-based learning can introduce the child to real life in the digital space, enabling them to understand problems and science-based in real life. This feature, which is the only special of these games, is often made possible by creating three-dimensional space and other scientific and visual phenomena.

Some teachers and parents also believed that if this feature of digital games (the ability to reconstruct and simulate the real three-dimensional world) was combined with other sciences such as geography, social sciences, history, linguistics, and art, it would increase children's learning and knowledge skills. Consequently, educational games based on education can be said to improve children's ability to solve learning problems and accelerate interaction, easier understanding of lesson issues, and increase the rate of learning. However, further studies are needed to make the ambiguities clearer regarding this issue. These include understanding how these games and new technology work on other types of children's skills.

What were highlighted in this thesis are the important implications of creativity, play, and how to increase learning in preschool children. Teachers are also encouraged to use these

games to teach in the classroom to facilitate the transfer of knowledge to playful young children. On the other hand, teachers, parents, and play designers must have the knowledge and experience to understand how to nurture children's creativity in order to interact with their learning. The data and the results indicate that education-based digital games should be designed in such a way as to provide sufficient independence in practice for children within the framework of the principles of education. This independence will result in more creativity in children, increase their experience in different areas of education, and institutionalize the curriculum in the subconscious mind of children and be more effective and capable than traditional methods.

In summary, what can be said from the collection of observations and data is that digital games based on education lead to entertainment, fast interaction, creativity, increased social skills and cooperation along with improved learning. Teachers stated that due to the special features of DGBL games, the financial costs of doing creative projects for young children can be reduced. It should be noted that teachers and schools needed to spend money on the existence of facilities such as paint, paper, and other materials to do experiments and creative activities in the classical and traditional non-digital environment. While in digital games without any cost to have all these items in one place in a higher-quality space, make it feasible to do all these experiments and creative activities. However, the extent of the impact of these games on children on various topics remains unclear and further research is accordingly needed.

Thus, the findings from a set of data, observations, and interviews indicate that once programmers wish to design more effective DGBL programs in terms of creativity and learning, they ought to focus more on a few features of these games. For example, teachers and parents should be able to change the curriculum and educational level in the game settings when using these digital educational games. As preschoolers between the age of 3 to 6 are in

their age of playfulness, if parents and teachers have the ability to change the educational level of the programs in the settings, they can adjust the games to the level of interest and curiosity of the children.

Therefore, teachers can attract the child to play and teach lessons. Otherwise, the child may become bored and the challenges may be too hard for the child to solve and therefore the child may give up digital play. As a result, teachers can measure children's creativity and learning by determining the level of challenging, activating, and deactivating it in settings.

While there is evidence that children use games on other operating systems or hardware such as the Xbox, etc., according to recent research on increasing children's access to tablets and digital technology, the use of tablets has become a major toy for children. Therefore, parents, psychologists, and teachers should be aware of the quality of the programs because enough insight makes a difference in the choice of DGBL applications on market to develop children's skills. Consequently, it is necessary to emphasize more research and gain more knowledge about this emerging technology.

In addition, teachers can help children understand and solve problems and issues in the digital environment, thereby empowering them to deal with real-life problems.

Therefore, this part of the research has a great impact on children's future life since the capabilities of digital games in terms of innovation in the conscious empowerment of the mind to create and discover solutions to problems, cause children to find solutions to life and empower themselves in case problems pose.

As previously noted, this study provides insights, enlightening recommendations, and effective suggestions for game designers and developers in digital games based on education as well as researchers, teachers, and psychologists to enhance creative skills and critical thinking, motivate, and improve outcomes and learning in young children.

6.2.2 Results: Research Objective 2

The second research objective was: To develop a model that integrates content, behavioral, and applying components of creativity, roles, and relationship with learning in DGBL apps for preschool level.

Designing and developing a model that integrated applying components of creativity, roles, and relationship with learning in DGBL apps for the preschool level were facilitated by the key findings from the first experiment in this thesis.

These findings guided this thesis to design and implement a simple prototype of STEM-based learning apps for preschool level based on the proposed model of DGBL apps. Indeed, the answer to the second objective was the summary of the most important findings from the second experiment that was to evaluate the proposed DGBL model based on STEM, which includes four sections:

1. DGBL principles and training in DGBL prototype based on STEM and the proposed model.

2. Creative thinking in the DGBL prototype based on STEM and the proposed model.

3. Types of games based on the proposed model.

4. Game Difficulties.

The results show that creative thinking and learning activities in STEM-based learning programs are enhanced among preschool children. The potential of using the components of creativity in educational games causes the child to experience meaningful play in the digital space. This means that children in the early stages of life learn to enjoy life while thinking about things and actively explore and listen to their surroundings.

Therefore, the theories mentioned in this study, along with creativity, in the digital learning environment can be said to allow the learner to use his/her creative thinking and implementation as a guide for his/her curriculum. Hence, this study points out the factors that strengthen children's motivation in attracting space of virtual reality for learning and creativity, transfer their knowledge, and recognizes their ability to detect orientation in learning. The result of this research also demonstrated fostering creativity and learning for young children in DGBL environments was better than traditional school teaching methods.

6.2.3 Results: Research Objective 3 & 4

The third and fourth research objectives were: To design and implement a prototype of a game-based learning STEM app for preschooler level based on the proposed model of DGBL apps. Then the proposed model of game-based learning and creativity apps was evaluated.

This part of the study strives to investigate the effects of the proposed model of game-based learning app on creativity and learning STEM among young children, teachers, and parents in the teaching environment such as school or kindergarten.

A deeper look at understanding the dimensions of creativity and its characteristics shows that the cultural and economic consequences of the 21st century showed that teaching methods in connection with children need to be changed in the early stages. Due to the importance of creativity in strengthening learning, especially in the STEM dimension, a list of outstanding topics was identified, which shows how kindergarten and preschool environments may influence the development of creative skills and learning in DGBL at the preschool level. Based on the answers obtained from interviews and observations, some of the identified topics are as follows;

1. Children's participation in digital educational games allowed the teachers to learn more about their creative and social skills and fostered those skills.

2. Responding warmly and responsibly to children on the part of teachers and parents increases their self-confidence.

3. Using DGBL in the STEM-based learning prototype provides opportunities for children to explore more, become aware of their creative skills, and facilitate learning.

4. DGBL leads to social skills, creativity, and learning.

5. Using DGBL in the STEM-based learning prototype encourages critical thinking and exploration.

6. Observation allows teachers to learn more about children's creative skills.

7. Providing opportunities for children to participate in the use of DGBL and iPad technology will stimulate their ability to think differently and creatively in real-life situations.

8. Encouraging DGBL games allows children to learn how to share, negotiate, and solve problems collectively.

9. Providing a curriculum using digital technology, DGBL, and boosting creativity allow children to creatively explore, experiment, hypothesize, and think.

The findings suggest that creative opportunities and children's learning can be developed if digital technology is used in preschool environments. Therefore, based on the interpretation of the findings, the use of DGBL digital technology can also help children in their academic achievement.

6.3 Discussion of the Results in Relation to the Literature

As mentioned earlier, what is important for children's cognitive development is the close relationship between children's play and the emergence and growth of creativity in children. At the same time, play and creativity increase children's experience and learning from their environment. According to recent studies, most researchers have used “Vygotsky's theory” in their studies of creativity and play in young children (Vygotsky, 1987). Furthermore, "Vygotsky's theory" refers to the close relationship between creativity play in children's intellectual and physical development.

A number of researchers have examined children's creative use of digital technology and areas such as photography or drawing (Verenikina and Kervin, 2011). But the direction of recent research on the extent to which digital technology affects children's creative mental development and learning is still unclear. Therefore, Therefore, this thesis answers this hypothesis.

During an understanding of knowledge for young children, there are numerous problems or gaps. During educating young children, creativity is seen as a helping flow, a solution, or even a deep learning process (Hui, Hoe et al., 2014). On the other hand, the use of art can also be used as a creative advocate for a better understanding of knowledge in young children (Schäfer, 2015). The present study also shows that in young children, learning in educational games, with an enjoyable experience by bridging the gap between creativity and science, can enhance learning, as some researchers have noted in their research (Schumm and Bogner, 2016; Epstein and Fischer, 2017).

Therefore, in learning applications, integrating arts or creative aspects can have a positive effect on learning. Applying art and creativity to STEM learning in educational games promotes critical thinking (Henriksen, 2014). This positive impact can also be effective in

children's real life, causing creative thinking to solve real-world problems and more. On the other hand, STEM can improve children's imagination and motivation, both of which are very applicable to real-life for them.

Creativity can also be said not to be an exclusive domain of art, but it creates mental abilities in all aspects of life and perhaps particularly in the field of scientific research. Creativity in STEM helps to transmit enthusiasm and supports individual self-efficacy and fills the gap between art and STEM (Runco, Acar et al., 2017). Given the deeper understanding of the dimensions of creativity and its characteristics and the consequences of 21st-century culture and economics, children's education methods must be changed in the early stages (Chen and Lo, 2019).

As the National Learning Studies has pointed out, one of the most important components of success in teaching and transferring knowledge to students is to enjoy sufficient skills and knowledge in how to teach (Darling-Hammond, Hyler et al., 2017). Besides, recent research has confirmed that teachers' professional development in terms of skills and knowledge increases the quality and effectiveness of their teaching (Shakman, Zweig et al., 2016).

Therefore, reviewing the observations and interviews conducted in this study, the results indicate that once teachers have sufficient knowledge in the use of digital games, they can use this new technology as a new tool to transfer knowledge faster and easier to use it to young children. At the same time, children and teachers feel more comfortable when using these digital educational games.

A number of teachers and parents also stated that they want to hold appropriate courses to use this technology. They maintained that most of them failed to become acquainted with such a specialized course in the use of digital technologies during their academic studies or careers. What is certain is that teachers and parents with these skills and sufficient knowledge of the

use of digital technology in digital educational games can more effectively guide young children and examine their behavior (Pittman and Gaines, 2015). Discovering the world of calm and quiet children is possible through these games and teachers can enter their world through easy educational games and measure their level of learning by observing their behavior and response in various science fields in applications.

On the other hand, teachers and parents in this interview did mention their ideal environment in the world of technology and virtual digital games. They called for a digital game environment that enables them to change and control agents. Examining more digital preschool games evaluated in this study, it is obvious that teachers need to receive enough train in computer science education and professional development in this field and the lack of information in this field is evident. The data collected from teachers and parents as well as children show such challenges as lack of time, lack of suitable opportunities for further development in learning in digital games, and lack of appropriate educational games for this age group. For example, not all schools have access to tablets or new technologies or tools to run education-based digital games.

The approach of many games based on learning in the digital learning environment has been thinking and computing skills in a fun learning environment, including games designed for STEM. The purpose of designing such new digital educational environments for users is to increase the participation of teachers and students in intellectual activities such as solving the problem of creative and critical thinking. These games not only increase the knowledge and skills to solve problems but also encourage the user to achieve goals (Qian and Clark, 2016). While many teachers and parents did not fully understand what new technology such as tablets are or how digital game-based learning is used, all of them as participants realized that children's learning was important. They went on explaining that computer science should be included in various criteria such as English language arts, mathematics, and science.

As discussed earlier, the use of digital game technologies can provide the basis for increasing the intensity of education and serving as a motivational component for children who have difficulty with traditional learning tools (Nelson-Walker, Doabler et al., 2013). Stewart (2013) also noted that the use of digital educational games to learn, especially for disinterested children, leads to increased motivation and confidence (Stewart, Bleumers et al., 2013). Novak (2015) also confirmed that, based on research, digital game-based learning can facilitate active learning (Novak, 2015). This not only affects learning outcomes, but also engages and motivates the learner. The data and observations of this thesis also indicated that participants were motivated and engaged when using technology. Meanwhile, teachers explained the main factor in choosing to use technology in general and digital game-based learning in the education of young children in particular.

Teachers and parents believed that digital game-based learning was an effective educational tool and wished to apply it more in teaching children. They believed that more professional and effective training was needed for the constant use of digital game-based learning. Teachers feel that the value of digital game-based learning fun for preschool children helps them learn the information and concepts through which the program is taught. Teachers and parents also explained the need to combine students to learn computational thinking skills and the motivation for engaging in digital games to teach new technologies such as tablets. However, there is no specific curriculum for what 21st-century preschool learning should entail, but it is accepted that digital games should be included (Jenson and Droumeva, 2016).

6.4 Strengths and limitations of the thesis

Since a wide range of creative activities through game-based learning apps is increasing, this study addresses components of creativity, specifically on the features that can foster creativity. Preschoolers (3-6-years-old) as participants were selected from Montessori school since its curriculum education is based on learning through playing the game for data

collection. The qualitative method (case study) analysis was studied to provide a better conceptual model and prototype of game-based learning apps for fostering preschoolers' creativity in order to improve learning STEM using four categories of features: promotion of creativity, the taxonomy of play types, Principles of DGBL, overall design and supporting (scaffolding) of use. This study also investigates the pedagogy scheme as a facilitator to develop a conceptual model of game-based learning apps for creativity assessment in DGBL for enhancing learning STEM. Consequently, the strengths of this thesis are:

- A model of game-based learning apps for fostering creativity skills to improve learning STEM at the preschool level
- The study proposes a set of components of creativity that improves learning STEM by using DGBL apps among young children
- A pedagogy assessment in DGBL apps that can be used to enhance creativity and learning STEM at the preschool level.

Recent studies have shown that the use of video recording techniques from participants' activities has prominent strengths, indicate that this method is very useful (Marsh, Plowman et al., 2018).

On the other hand, the study through film recording can be used to complete other research and qualitative approaches such as interviews and observations of participants. In interviews, only observers and researchers ask specific questions from participants and record their responses, while other aspects of the participants' behavior remain uncertain.

However, in video recording, this behavioral dimension of the participants' can be repeatedly analyzed by researchers. In interviews and writing, with limited time schedules and official settings limited to a specific phenomenon, which in fact limits the possibility of

examining further dimensions of research to the researcher. In a similar situation, it is possible to record participants' observations that researchers may be in one field for a limited time, which may also prevent the perceived aspects of the participants' behavior.

Also, the study of participants' perceptions and feelings about the subject at various times during the written interviews would be confusing (Brandt, Weiss et al., 2007). Without observers, the video recording method, like other methods, can also be said to be limited by the participants during the interview. For example, the participants chosen by the researchers for collecting data may sometimes remove certain data that is unimportant in view of the participant, while such data may be important for researchers.

As mentioned above, limitations, shortcomings, and certain conditions are not usually under the control of the researcher (Creswell, 2021). These limitations can also affect research results. In this study, what was beyond the researcher's control included time and sample size.

6.4.1 Time Constraints

Due to the nature of the daily work schedule in this study, there was a time limit for both the teachers and parents as to interviews and observations. In the present study, teachers and parents were given a 45-minute preparation period. Interviews took place during these periods without interrupting teachers' or children's school planning or lunch. Teachers' observations were made during the day after school time, approximately from 4-6 p.m. Each training course took approximately 20 minutes in length during the observation course, described in detail in previous chapters.

6.4.2 Sample Size

In this thesis, the number of participants is very small. This small number of participants indicates that the result in a large group of young children may differ from this research. Thus, for future studies, a large number of participants for more accuracy in the result are suggested.

6.5 Implications of the Results

In this section, the results obtained from the present study are discussed. This thesis relates the results to the purposeful model. This research also explains the implications of this study in relation to the literature. While research has shown that the development of high-quality careers combined with the use of technology is a major factor in improving the quality of learning in children (Skourdoumbis, 2014; Green and Allen, 2015; Shakman, Zweig et al. 2016; Darling-Hammond, Hyler et al., 2017), the results of this study show that in Montessori kindergarten, teachers failed to use and access technology in teaching the children different subjects.

It is also worth mentioning that many teachers and parents were not trained in the use of technology or educational applications in their courses.

On the other hand, the results of this study showed that digital play-based learning increases children's employment and motivation. DGBL increases students' desire and effort to understand and learn topics in STEM, self-regulated actions, and display of solutions at the preschool level. This type of learning can also provide a basis for increasing the intensity of teaching, especially for children having problems with traditional tools during education.

In addition to the contribution of these findings to the existing body of knowledge, teachers, managers of application design companies, psychologists and parents can benefit from the findings of this research. Teachers noted that they needed more support and resources from principals and other teachers. Instead of focusing entirely on performance, stakeholders

can design curricula on child-related topics and projects in which they can use new technologies such as tablets to solve problems independently in group settings.

Some teachers stated that they needed more professional classes to acquire the skills needed to determine how to identify skills in young children. Providing workshops and educational programs that focus on shaping the teachers' awareness on how to use and operate new technology and digital educational games to foster the creativity and learning of preschool children can help decrease a gap.

Teachers also maintained that parental involvement in the use of this technology could be an appropriate approach to social and creative experiences at school. The home environment can be an extension of the development of interpersonal relationships and creative skills.

Therefore, the necessary seminar classes are suggested to design for parents to help support preschool environments and improve children's intellectual skills as well as identify the characteristics of creative children.

6.6 Recommendations for future research

The main purpose of this thesis is to investigate whether DGBL technology (tablet and smartphone) can improve children's creative skills at the age of 3-6 and how this development will affect children's learning. To conduct this study, seven preschool children, two teachers, and seven selected parents were used from Montessori Preschool as participants.

Montessori focuses on a method known as "ready environment" in that the materials and activities in the environment are organized with the least help from the teacher to facilitate independent learning and exploration by the child (Richardson, 2000).

Hence, further study on this topic could include a larger sample, participants' choice of kindergartens and public school preschool environments to determine whether there is a

difference in teachers' and parents' perceptions of how digital gaming technology is based. Education may affect the development of preschool children's learning skills and creativity.

Future studies may select a large sample of teachers to determine how preschool and cyberspace environments develop the use of education-based digital games based on children's creative and social skills or their level of learning. In the "Reggio Emilia" method, the environment such as nature and cyberspace is referred to as the "third teacher" where materials and space are organized to enhance creative skills and learning.

Comparing "Reggio Emilia" and "Montessori" methods with other public-private schools and the charter can provide other insights into how to prepare digital preschool games to foster creative skills and learning.

The following are some recommendations for future research from this thesis:

1. Integrating traditional and classic games in the real world of children with the virtual world in applications is a good way, making these applications more attractive and interactive.

2. Using children's favorite TV characters' increases children's attention and develops their imagination and creativity by showing these games in cyberspace with their favorite characters.

3. These digital educational games also create a creative, objective, and pre-acquired space in the virtual world.

4. Due to the attractiveness and interaction DGBLs have with children, cause children to spend more time and this is also involved in fostering children's creativity.

5. Most of the children's creative activities have been observed in digital games, which had topics or sections such as storytelling, interactive and visual books, painting, and coloring. This shows the profound psychological impact of these DGBLs on the psyche of children, in terms of play on the creative mind and thought process of children in the subject of learning. In this way, children become interested in writing the letters of the alphabet using these digital games and practice more.

6. Some applications such as Lego and Minecraft cause a significant increase in creativity (especially in constructing) in children.

7. From the world of art, music also plays an important role in the world of children. Listening to music made by the children themselves is enjoyable for children and opens a new world of art to them.

8. These apps encourage children to ask teachers, parents, or peers to accompany, play, and sometimes even get help. It also subconsciously affects children's social skills and social communication after stimulating their activities.

9. DGBL application stimulates their imagination and curiosity. In the next step, children try to identify the new knowledge presented in the games by using their previous knowledge and try to present a new hypothesis or idea. This shows the inclination of children to creative and critical thinking and intellectual flexibility to the originality of divergent thinking.

10. Applications in which designers incorporate issues such as problem-solving, exploring, critical thinking encourages children to ask more questions, explore, or solve problems. These apps help children to improve more creativity and learning.

6.7 Areas of Improvement

Evidence suggests that combining the components of creativity and learning in a single model or framework may provide better performance in retrieving learning and creativity for preschoolers. Another limitation reported is that young students are overly focused on virtual information, with results suggesting that children are overly attracted to virtual space and images of complex DGBL systems and creative components. Hence, the result of studies for the evaluation of learning in DGBL indicated moderate learning.

In addition, assessment courses are too short to assess student performance and learning, requiring longer evaluation and long-term experience. The content for preschool children should be designed in a way that is clearly understandable to children, and also the content in DGBL games should be relevant and consistent with the learning objectives set at the preschool level.

Case studies help to identify the most appropriate elements for children to focus more on learning and teaching topics and increase the creativity and special needs of specific educational topics. More research needs to be carried out on how to create and DGBL program so that teachers can more easily pass on the basics of early childhood education to young children.

Teachers play an important role in accompanying and influencing DGBL games, as the quality of their teaching helps to attract children's attention to digital educational game environments.

Therefore, the necessary guidelines should be developed for the standard design of DGBL games in the field of creative learning for the preschool level.

6.8 Participants

The increase in the number of participants from other schools could lead to results that may be in the interest of digital game designers, school principals, school psychologists, and lead to richer and more accurate analysis. As already mentioned, this study was limited to two teachers and seven parents as well as seven children.

However, most of the adults participating in this study were women because the entire classroom and school-specific workshop were female. The presence of male teachers can provide a more diverse set of data for future researchers.

Another set of data and interviews to be helpful in future research is the use of technology teachers and the necessary knowledge in the field of education-based digital games. These teachers have a unique perspective on new technology owing to the nature of their profession for they were specifically trained in digital technology. How these teachers teach and what they recommend can be the focus of future research. Even preschool teachers may be able to achieve this professional advancement in computer science education and DGBL via taking a course in digital technology education.

6.10 Conclusion

The data collection in the present study was provided through interviews and observations from teachers, parents, and preschoolers (aged 3 to 6) to find out how DGBL games help creativity and children in STEM learning. The main question was "What components foster children's creativity and play, and to what extent does this fostering creativity affect children's learning in the digital space?"

Hence, the relationship between creativity and divergent thinking, play, and learning in children was examined in two stages of the first and second experiments. The role of teachers in both stages of the experiment was also examined. Teachers played an important role in

creating new attitudes and motivating as well as stimulating students' creativity and skills in using digital games and the amount of learning in the DGBL space. Even teachers can help children cope with the challenges of DGBL environments to prepare them to deal with real-life problems. This, in turn, teaches children problem-solving skills when facing with real-life problems.

This research examines the conscious empowerment of children's minds to solve problems through the use of creativity and divergent thinking skills. The present study provides a new perspective on education for DGBL researchers, game designers, teachers, and psychologists. Besides, this thesis offers new insights and effective suggestions on how to increase creative and divergent thinking skills, social skills of collaboration, and critical thinking together with its relationship to children's learning in STEM-based learning games at the preschool level.

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