EVALUATION OF AN ENHANCED GAME BASED LEARNING FRAMEWORK THROUGH VLE

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EVALUATION OF AN ENHANCED GAME BASED LEARNING FRAMEWORK THROUGH VLE

ABSTRACT

The effectiveness of an education system is highly dependent on the teaching and learning approaches used. The conventional ways of teaching and learning are no longer sufficient to ensure quality of education as well as engage students' interest in learning, especially in this digital era. Various research have focused on creating effective teaching and learning environments to enhance the traditional approach. Game-based learning (GBL) utilises the gaming environment to attract the student's attention and increase participation throughout the process of learning. Although GBL has been present in the Malaysian preschool curriculum since the last decade, GBL is still not being practiced in the formal education system in Malaysia. The factors that have caused low adoption of GBL in Malaysia include the limitations of existing GBL frameworks, barriers to teacher's adoption of GBL and issues regarding transfer of knowledge. To study and counteract against these challenges, this research proposes a GBL framework that focuses on the development of language and communication, cognitive, and psychomotor skills for preschool children. A learning system using virtual learning environment (VLE) was designed to evaluate the effectiveness of the proposed framework in promoting learning for preschool children. Two surveys were used to identify the scope of the syllabus for the proposed learning system and to gauge its usefulness in achieving research objectives. 84 preschool children participated in this study. Their learning performances were evaluated through a quasi-experimental approach. The results show that learning performance improved significantly, and moreover, the learning system increases the teacher's willingness to adopt GBL for preschool children.

Keywords: children, development, framework, game, learning

PENILAIAN KEPERLUAN PEMBELAJARAN BERASASKAN PERMAINAN MELALUI VLE

ABSTRAK

Keberkesanan sistem pendidikan adalah banyak bergantung kepada kaedah pengajaran dan pembelajaran yang digunakan. Cara-cara pengajaran dan pembelajaran konvensional tidak lagi mencukupi untuk mengekalkan kualiti pendidikan serta menarik minat pelajar dalam pembelajaran dalam era digital ini. Terdapat pelbagai penyelidikan yang memberi tumpuan kepada teknik pengajaran dan suasana pembelajaran yang berkesan demi meningkatkan cara pembelajaran tradisional. Pembelajaran Berasaskan Permainan (GBL) menggunakan permainan untuk menarik perhatian dan meningkatkan penglibatan pelajar dalam proses pembelajaran. Walaupun GBL wujud dalam kurikulum prasekolah di Malaysia sejak sedekad lalu, GBL masih tidak diamalkan dalam system pendidikan rasmi di Malaysia. Faktor-faktor yang menyebabkan penggunaan GBL di Malaysia terhad termasuk kekurangan dalam perangka GBL yang sediaada, halangan-halangan yang dihadapi oleh guru menggunakan GBL, serta isu-isu mengenai pemindahan pengetahuan. Oleh itu, kajian ini telah mencadangkan satu perangka GBL yang member tumpuan kepada perkembangan bahasa dan komunikasi, kognitif, dan kemahiran psikomotor untuk kanak-kanak prasekolah. Sistem pembelajaran berasaskan persekitaran pembelajaranmaya (VLE) direka untuk menilai keberkesanan perangka GBL yang dicadangkan demi menggalakkan pembelajaran untuk kanak-kanak prasekolah. Dua kaji selidik telah digunakan untuk mengenalpasti skop kurikulum untuk system pembelajaran yang dicadangkan dan kegunaannya dalam mencapai objektif kajian. 84 kanak-kanak pra-sekolah telah mengambil bahagian dalam kajian ini. Prestasi pembelajaran mereka dinilai melalui pendekatan kuasi-eksperimen. Keputusan menunjukkan bahawa prestasi pembelajaran telah meningkat dengan ketara.

Selain itu, system pembelajaran juga meningkatkan kesediaan guru dalam penggunaan GBL untuk pembelajaran kanak-kanak prasekolah.

Kata kunci: kanak-kanak, pembangunan, perangka, permainan, pembelajaran

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LIST OF ABBREVIATIONS

ANOVA	:	Analysis of Variance
ANCOVA	:	Analysis of Covariance
AVG	:	Active Video Games
CAVE	:	Cave Automatic Virtual Environment
CL	:	Confidence Level
CPU	:	Central Processing Unit
DNN	:	Deep Neural Network
Dr.	:	Doctor
DTW	:	Dynamic Time Warping
ECCE	:	Early Childhood Care and Education
GBL	:	Game-based Learning
GUI	:	Graphical User Interface
GIGL	:	Gesture interactive GBL
GOM	:	Game Object Model
HMD	:	Head-Mounted Display
HMM	:	Hidden Markov Models
ICT	:	Information and communication technologies
IR	:	Infrared
IPO	:	Input-Process-Outcome
MANOVA	:	Multivariate Analysis of Covariance
m	:	Mean
MOE	:	Ministry of Education
NICE	:	Narrative-based, Immersive, Constructionist/Collaborative Environment

Q & A	:	Question and Answer
RGB	:	Red, Green, and Blue
RM	:	Ringgit Malaysia
Sig.	:	Significant
SD	:	Standard Deviation
TGMD-2	:	Test of Gross Motor Development, Second Edition
3D	:	Three Dimensional
2D	:	Two Dimensional
UNESCO	:	United Nations Educational, Scientific and Cultural Organization
VLE	:	Virtual Learning Environment
VR	:	Virtual Reality
XML	:	Extensible Mark-up Language

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CHAPTER 1: INTRODUCTION

1.1 Background

There exists a body of research that focuses on creating effective teaching and learning environments to enhance the traditional approach. The effectiveness of an education system is much dependent on the teaching and learning approach used. Conventional classroom approach is a traditional teaching and learning approach. This approach relies on teachers to conduct classes/lectures in a classroom, with students asking questions during the classes/lectures to receive immediate feedback. It is also is based on direct teacher instruction and printed learning materials such as textbooks. Therefore, this approach has time and location constraints. In addition, success of the direct instruction as a method very much depends on level of knowledge and the amount of preparation work that has been done (Zhang, Zhao, Zhou, & Nunamaker Jr, 2004).

An E-learning system is introduced to overcome the time and location challenges faced by the conventional classroom approach. E-learning is a learning environment that utilises the information and communication technologies (ICT) infrastructure for teaching and learning activities. Teachers can conduct classes/lectures in different remote locations and students can access the online learning materials as well as the recorded classes/lectures anywhere and anytime. Moreover, some e-learning features allow students to post questions via forums and teachers can reply through them. Although an e-learning approach can solve the time and location constraints, other challenges emerge with this approach. For example, most e-learning systems do not support real time interactions between teacher and students (Cantoni, Cellario, & Porta, 2004; King & Piotrowski, 2015). However, interactions between teacher and students are crucial for the development of communication skills, especially in early childhood education (Cabell, Justice, McGinty, DeCoster, & Forston, 2015; Downer et al., 2012; Hutinger, 1978; Kirkland & Patterson, 2005; Piker & Rex, 2008). Children with interaction issues often have problems expressing themselves because they have difficulty understanding the words that other children/teachers use and/or putting their own ideas into words when communicating with others.

Besides, students with different learning styles may face difficulty adapting with the e-learning environment (Truong, 2016). There are seven learning styles – Visual, Aural, Verbal, Physical, Logical, Social, and Solitary (Henderson, Shurville, Fernstrom, & Zajac, 2009; McLawhon & Cutright, 2012; Morsi, Smith, & DeLoatch, 2007). For example, students who have a social learning style might have difficulty using the e-learning environment to practice learning because they prefer group discussion.

Since e-learning allows teachers to be absent during learning, students must be self-disciplined and eager to participate in all the e-learning activities which have been designed for them in good-faith. Students who are easily distracted might find e-learning systems not beneficial to them.

In order to attract students' attentions in learning, multimedia learning is introduced. Multimedia learning makes use of the presentation form of learning materials like words and picture, animation, as well as audio and video to attract the attention of students (Mayer, 2003). In the multimedia learning approach, the teacher conducts classes/lectures using multimedia packages either in the classroom or through the e-learning system. Research has reported that students' interest increased with the use of multimedia learning (Mayer, 2001). Results of a survey by from Fernández-Molina, Trella, and Barros (2015) reported that there was a significant improvement in students' scores after incorporating e-learning with multimedia packages for preschool education.

However, some research claimed that the use of multimedia materials might hinder learning under certain circumstances (Cutrim Schmid, 2008). For example, multimedia materials may be more effective in teaching procedural tasks (sequence/steps for a process or an event) when compared with conceptual (abstract idea or general notion) and causal learning (cause-and-effect chains) (Van Genuchten, Scheiter, & Schüler, 2012). Furthermore, the inappropriate design and application of multimedia instructional materials can distract students and inhibit their learning outcomes (Lee, Hsiao, & Ho, 2014). Sakar and Ercetin (2005) reported that students experienced cognitive overload due to excessive processing of visual and audio information while using multimedia annotations to facilitate the learning of reading comprehension.

On the other hands, Woo (2014) stated that the cognitive theory for multimedia learning has its limitation on examining the motivational factors such as attention, relevance, confidence, and satisfaction for learning. Digital games, with characteristics of fantasy, fun, competition, challenges, goal-oriented tasks, and multimodal presentation, readily appear to offer the aforementioned motivational factors in sustaining the students' attention and interest of learning.

In recent years, some research have demonstrated that game based learning (GBL) can enhance student' learning interest and motivation (Chen & Law, 2015; Erhel & Jamet, 2013; Sun, 2013). GBL is a type of game play that is designed to teach students in a specific subject. This approach engages the students into an immersive simulated environment and motivates them through the competitive activities with rules, goals, feedbacks, interactions, and outcomes (Kim, Park, & Baek, 2009). Teachers can design a game that tailor to a subject while students learn the subject by playing the related game. A well designed GBL provides an entertainment medium that promotes learning, motivation as well as cognitive skills development. Although GBL seems to be a promising approach for effective teaching and learning, there exist some challenges such as teacher's role in adopting GBL for classroom learning, the appropriateness of design and use of content, and transfer of knowledge.

1.2 Motivation

Many GBL studies indicated positive gains in the achievement of desired learning goals for cognitive development such as knowledge acquisition (Hwang, Chu, Lin, & Tsai, 2011; Ward, Finley, Keil, & Clay, 2013), literacy (Beschorner & Hutchison, 2013; Couse & Chen, 2010; Neumann & Neumann, 2014), and problem solving (Chang, Chen, & Hsu, 2011; Sánchez & Olivares, 2011). However, teachers encountered problems in GBL due to a lack of familiarity with introduced games and the varying approaches in student assessment requirements used in different subjects. The integration of game with curriculum required careful analysis of how game features are systematically aligned with those of pedagogy and curriculum (Graesser, Chipman, Leeming, & Biedenbach, 2009). Furthermore, teachers' attitudes and efforts strongly influence the motivation and learning performances of students in a game.

Although the literature on GBL is growing fast, the effectiveness of GBL in promoting learning still remains unclear especially for knowledge transfer (Gros, 2007; Wong et al., 2009). Scaffolding (Chen & Law, 2016) has been recommended for GBL to improve academic learning performance for knowledge acquisition and problem solving. Sun, Wang, and Chan (2011) used a digital Sudoku game (Professor Sudoku) to classify and investigate the effect of built-in critical features, frustration control, and demonstration scaffolds on learner behaviours. The research showed that scaffolding support increased the level at which puzzles could be solved, and decreased frustration resulting from excessive numbers of retries. However, it may be that student reliance on scaffolding support can reduce learning opportunities such as solving the problems through trial-and-error. Therefore, the use of technology-enhanced scaffolding has to be carefully designed to overcome frustration when learning. Some research has shown that the presence of teachers have positive effects on the students' learning (Amerian, Ahmadian, & Mehri, 2014; Lee, 2016). It has been suggested that technology-enhanced scaffolding in GBL with the involvement of teacher guidance promote and enhance learning (Kim & Hannafin, 2011).

Recent studies have shown that psychomotor development has a positive impact on cognitive performance (Angevaren, Aufdemkampe, Verhaar, Aleman, & Vanhees, 2008; Keeley & Fox, 2009; Pompeu et al., 2012; Staiano & Calvert, 2011) apart from enhancing motor skills and improving health. However, GBL research on the areas of psychomotor development targeting preschool children is sparse (Hsiao & Chen, 2016; Lin & Hou, 2015). Hsiao and Chen (2016) compared the gesture interactive GBL (GIGL) approach with the traditional classroom game approach in enhancing preschool children's psychomotor development. They found that children using the GIGL approach outperformed those who learnt using traditional classroom game approach. This study sheds light on the potential of GBL in psychomotor development for preschool children.

Based on the above literature review, it is clear that there is still room for improvement in the deployment of GBL in preschool curriculum to achieve better learning. It provides the motivation to carry out this research to propose an effective preschool learning system that focuses on the cognitive and psychomotor development for preschool children, importantly, one which includes enhancements to the existing GBL framework.

1.3 Statement of Problem

GBL has been present in the Malaysian preschool curriculum since year 2001 (Ministry of Education, 2001; Noor Azli, Nor Azan, & Shamsul Bahri, 2008). Undoubtedly, children enjoy learning through games more when compared with learning via reading books, working with worksheets or receiving information on a whiteboard. And yet, GBL is still not being practiced in the formal education system in Malaysia (Hussain, Tan, & Idris, 2014). The factors that have caused low levels of usage of GBL in Malaysia include limitations of existing GBL frameworks, barriers to teacher adoption of GBL, as well as issues regarding transfer of knowledge.

1.3.1 Limitations of Existing GBL Frameworks

Although recent studies have shown promising results of GBL as a more effective teaching method than conventional methods in fostering the learning and engaging the children to learn (All, Nuñez Castellar, & Van Looy, 2016; Hsiao & Chen, 2016; Wouters & Van Oostendorp, 2013), existing GBL frameworks such as Input-Process-Outcome (IPO) game model (Garris, Ahlers, & Driskell, 2002) and Game-based learning framework (Van Staalduinen & de Freitas, 2011) failed to convince school stakeholders and teachers to implement GBL in schools. This is due to the some limitations in the existing GBL frameworks.

IPO promotes learning from the game's perspective and emphasises the process of engagement that underlies game play (Garris et al., 2002). The narrowness of its focal point on player-game relationship (engagement) has neglected other important factors in facilitating learning such as learning objectives (Frank, 2011) and context (Berg Marklund, 2015). This model may lead the teacher to the wrong perception that GBL is not an effective learning approach. Since the framework was focused more on game play without being coupled with learning objectives, students learnt how to play the game rather than achieve desired learning outcomes. Besides this, a game without an appropriate learning context may not facilitate learning. The learning context is essential to help students to connect the acquired knowledge and skills to their daily lives (Sung, Hwang, & Yen, 2015).

The Game-based learning framework proposed by Van Staalduinen and de Freitas (2011) addressed the above issues by providing guidelines for aligning learning, instruction, and assessment. These activities play an essential role in understanding the learning style and progress of a student and help the teacher to improve learning by adjusting the teaching strategy. However, the framework hinders the role of the teacher in many aspects of these activities (learning, instruction and assessment). GBL is an approach to assist the teacher and students in the teaching and learning process but does not expect students to learn alone. GBL becomes ineffective if students learn independently without the guidance, observation, and evaluation from the teacher (Young et al., 2012).

GBL is not to a replacement of teachers and classrooms (Steinkuehler & Chmiel, 2006). The presence of the teacher is crucial for preschool education as children need proper instruction and guidance throughout the learning process. Thus, there is a need to enhance the GBL framework (Van Staalduinen & de Freitas, 2011) by emphasising the teacher's role, such as degree of involvement, teaching instruction and evaluation, in order to encourage their adoption of GBL and to foster the game learning experience of preschool children.

1.3.2 Barriers for Teacher's Adoption of GBL

GBL often requires the use of software, advanced gaming devices, and technical setup to operate efficiently. In order to conduct GBL effectively, teachers have to play key roles in the integration of game package and technology for teaching and learning. Teachers usually decide on the type, frequency, and quantity of technology tools to be used in their curriculum design and lesson delivery (Teo, 2014). However, the lack of technical knowledge to handle the issues related to hardware and software during the lesson has prevented the adoption of GBL (Wachira & Keengwe, 2010).

Teaching with technology requires teachers to expand their knowledge of pedagogical practices across multiple aspects of the planning, implementation, and evaluation processes (Peggy A Ertmer & Ottenbreit-Leftwich, 2010). Bourgonjon et al. (2013) highlighted some of the issues that may challenge the teacher in using games for classroom learning such as technical problems (e.g. support and facilities) as well as decision-making about the right game to support the curriculum and classroom learning. Thus, the usage of technology among teachers has become one of the barriers to GBL adoption in schools.

Latif (2014) highlighted the key issues in implementing games for learning in Malaysia. Despite the availability of technological infrastructure and school support, teachers are nevertheless responsible for the preparation and adoption of games in classroom learning. Preparation is required for recognising and mapping the relationships between activities in the games and associated learning. In addition, teachers are required to switch their role from instructor to facilitator when conducting GBL. Teachers facilitate children's learning with guidance, opportunities, and encouragement to direct their own exploration of objects and academic topics, making teaching akin to a partnership between the teacher and the children (Lerkkanen et al., 2016). Due to lack of time for preparation as well as the amount of time needed to facilitate students, most teachers are not willing to conduct GBL in school.

In addition, most of the teachers studied have very little experience with educational games. They faced difficulties with the games due to the complexity of the GBL program (Johnson, Adams Beker, Estrada, & Freeman, 2014). Lack of familiarity with games demotivates teachers to explore the potential of games as an effective learning tool (Can & Cagiltay, 2006). Besides this, teachers can have difficulties promoting the use of games due to overly-complicated gaming technologies (Kenny & McDaniel, 2011). The adoption of GBL will only happen when the technology is easier to operate. Due to such low interest among teachers in adopting GBL, there is a need to propose an effective GBL approach that eases the preparation of teachers for teaching and assessing students.

1.3.3 Transfer of Knowledge

The issues regarding the transfer of knowledge and skills have long been debated, whether for textbook learning, classroom instruction or for an innovative learning approach such as GBL (Barnett & Ceci, 2002). The debate on GBL in promoting transfer of knowledge is even greater among researchers and educators because of its fantastical context, scaffolding, feedback, and appropriateness of content for academic learning (Gunter, Kenny, & Vick, 2008).

Fantastical context is common for GBL studies as this is one of the game's characteristics that can immerse a player — to play, and to stay with the game. It satisfies the needs or desires of an individual that are hard to achieve in real life, such as power, success, or fame through various fiction stories and imaginary characters (Asgari & Kaufman, 2004). Some researchers have ascribed to the view that integration of educational content with fantastical context may promote learning (Asgari & Kaufman, 2004; Gunter et al., 2008; Malone & Lepper, 1987). Besides, the use of fantastical context may contribute to far transfer as it is totally different from reality (Bossard, Kermarrec, Buche, & Tisseau, 2008). However, children's abilities to discern fantasy from reality are still questionable (Subrahmanyam, Greenfield, Kraut, & Gross, 2001). The use of a fantasy character might not be an effective strategy for teaching real world information to preschool children because they may have difficulty forming connections between what they learnt and their real lives (Richert, Shawber, Hoffman, & Taylor, 2009). The findings by Richert and Smith (2011) supported this claim. Young children are more likely to transfer problem solutions learnt from realistic context (use of real characters) than from fantastical context (use of fantasy characters). To ease the transfer of knowledge, a realistic or authentic context with real characters is recommended as the learning context for preschool learning.

Apart from the learning context, scaffolding and feedback (e.g. debriefing and assessment) can facilitate transfer and its underlying process (Alklind Taylor, 2014; Barnett & Ceci, 2002). Scaffolding is essential for helping students cope with the challenge of learning (e.g. understanding difficult concepts) and develop respective skills (e.g. cognitive and motor skill). Current trends in GBL studies tend to use technology-enhanced scaffolding (Barzilai & Blau, 2014; Demetriadis, Papadopoulos, Stamelos, & Fischer, 2008; Huang & Huang, 2015; Sun et al., 2011). However, there are drawbacks to this approach. Students may rely on the support of scaffolding and thereby reduce learning opportunities (Sun et al., 2011). Huang and Huang (2015) reported that scaffolding is successful in helping students complete vocabulary exercises but failed to assist them in retaining the memory of learned vocabulary. To allow the scaffolding to fully play its role in assisting learning, the design and use of scaffolding should be done in a flexible and adequate manner.

Feedback is used as a measurement of the effectiveness of knowledge transfer. Feedback can be categorised into corrective and explanatory in the form of system feedback or assessment. Corrective feedback and explanatory feedback are two common types of feedback used in GBL (Erhel & Jamet, 2013). Corrective feedback informs whether the given response/answer is correct or incorrect while explanatory feedback explains why the answer/response is right or wrong. Tsai, Tsai, and Lin (2015) questioned the use of corrective feedback in facilitating learning due to limited information provided. According to Moreno and Mayer (2007), students learn better with explanatory rather than corrective feedback alone. For some circumstances such as problem solving, explanatory feedback works well in explaining the nature of a problem and providing useful guidance for students to improve their solution or performance. Conversely, students may be left in uncertainty or confusion due to an explanation being too general and lengthy (Valerie J Shute, 2008). Another consideration for explanatory feedback is students' attention. A student may not pay good attention to lengthy or complicated feedback. In this condition, explanatory feedback fails to fulfil its purpose in facilitating effective learning. On the other hand, corrective feedback is more effective and straight forward for the student to correct the mistake instantly in the case of practice or skill training (e.g. literacy and motor skill development) (Hsiao & Chen, 2016; Muis, Ranellucci, Trevors, & Duffy, 2015). According to Espinet, Anderson, and Zelazo (2013), corrective feedback is essential in engaging the preschool children to learn effectively.

The conventional classroom method uses formal assessments, such as paper tests for subject matter, physical test for motor skill, and laboratory tests for laboratory competencies. Teachers are required to do paper marking for subject matter knowledge and direct evaluation for physical skill assessment. However, formal assessment has its drawback in equipping students with appropriate learning attitudes since the assessment task only focuses on what is to be assessed and rote memorization (Gibbs, Simpson, Gravestock, & Hills, 2005).

The use of game assessment in GBL is considered as secondary evaluation or informal assessment. Game assessment allows for a wider scope of skill evaluation such as cognitive (e.g. problem solving) and psychomotor skill (e.g. hand-eye coordination) through the interaction with the game itself (Valerie J Shute & Ke, 2012). Besides, game assessment offers not only the evidence of learning outcome but also detailed insights into the underlying learning process, student learning behaviour, and opportunities to improve learning through immediate feedback (Ifenthaler, Eseryel, & Ge, 2012). However, with current game assessments, teachers have faced difficulties in interpreting the data for student progress. Since game assessment is more beneficial compared to formal assessment, there is a need to create a simple assessment plan to ease execution in the conventional classroom. Additionally, training has to be provided for the teacher to ensure the assessment can reflect the student's actual learning progress and transfer of knowledge.

In addition, games are also facing challenges in the area of content learning. Although games cover content learning in many subject areas such as science education, mathematics, language arts, reading, physics, and health (Valerie J Shute & Ke, 2012), there is a lack of evidence to support the position that games can produce positive, systematic outcomes for content learning better than can traditional teaching methods (Gunter et al., 2008). Without properly incorporating learning content into game scenarios, the effectiveness of GBL might not be as good as expected (Sung et al., 2015). McFarlane, Sparrowhawk, and Heald (2002) reported that the mismatch between game content and curriculum content, together with the lack of opportunity to gain recognition for skill development, formed a barrier for integrating educational games into the primary and secondary curricula. Besides, the appropriateness of content can also affect motivation for learning. Sandberg, Maris, and Hoogendoorn (2014) conducted research promoting vocabulary learning in a gaming context via mobile phone for children aged 8 and 9 years old. Although the results demonstrated a greater improvement in vocabulary tests, the children actually spent less time with the learning material because the learning material (target words) on average were difficult for the children to understand. Wrongly matching learning content with the target children's level of knowledge caused the diminishing of motivation to learn after playing the game. Therefore, to assure the appropriateness of the learning content, teacher involvement during game design and development processes are essential.

Games can support content learning as well as promote cognitive skill development of preschool children. Problem solving, as an essential cognitive skill, is the most meaningful and important outcome for any kind of learning (De Corte, Linn, Mandl, & Verschaffel, 2013; Jonassen, 1997). It is a complex thinking process that involves other cognitive skills such as reasoning, decision-making and recognition skill (Jonassen, 1997; Whimbey, Lochhead, & Narode, 2013). As the nature of games encourages problem solving, many GBL studies have made this the core element for gameplay, in order to stimulate the development of diverse cognitive abilities.

Although many studies in the literature point to the achievement of positive gains for cognitive development such as knowledge acquisition (Hwang et al., 2011; Ward et al., 2013), literacy (Beschorner & Hutchison, 2013; Couse & Chen, 2010; Neumann & Neumann, 2014), and problem solving (Chang et al., 2011; Sánchez & Olivares, 2011), there are also issues related to the mapping between game activities and cognitive skills levels. Martinovic, Burgess, Pomerleau, and Marin (2016) suggested that the cognitive skills (planning, reasoning and problem solving) level required for a game have to match student age. There is a need to design game activities tailored to the cognitive skills level of preschool children to foster the transfer of knowledge.

Psychomotor development has a positive impact on cognitive performance; however, the use of GBL in facilitating psychomotor development is still a puzzle due to technological constraints. The mobile platform such as tablet and smart phone enables the use of GBL in a more convenient manner due to smaller size and mobility. However, the platform is only limited to fine motor skill development such as drawing (Vinter & Perruchet, 2002) and finger gesture (tap and drag) (Noorhidawati, Ghalebandi, & Hajar, 2015). Its potential for other psychomotor development (e.g. hand-eye coordination) is yet to be discovered. Additionally, these two platforms tend to promote individual rather than the group learning.

The use of somatosensory video consoles such as Xbox Kinect and Nintendo Wii help to address the above issues (Kirsch & Cross, 2015). Somatosensory video console allows the player to interact with the game through the movement of head, hands, and legs. Human-computer interaction is enhanced through sound control and gesture movement. Miles, Pop, Watt, Lawrence, and John (2012) and Sun (2015) reported that the use of a somatosensory video console in GBL provided an innovative approach for the psychomotor development of children. Consistent with their findings, Hsiao and Chen (2016) demonstrated that this approach improved the learning performance and psychomotor development of preschool children as compared to the traditional teaching method. The use of the somatosensory video console appears to be a suitable operating platform for GBL to improve psychomotor development.

1.4 Statement of Objectives

The aim of this research is to propose a GBL framework for selected preschools to assist teachers and students in improving the teaching and learning process. In order to achieve the aim, the set objectives are as follows:

O1. To propose a game-based learning (GBL) framework for selected preschools to

- assist teachers in teaching and assessing preschool children.
- improve preschool children's learning in terms of language and communication, cognitive, and psychomotor development.

O2. To design a virtual learning environment (VLE) based on the proposed framework.

O3. To evaluate the ability and capacity of the proposed framework to

- assist teachers in teaching and assessing preschool children.
- improve preschool children's learning in terms of language and communication, cognitive, and psychomotor development.

1.5 Scope of the Research

The scope of this research is as defined below, to ensure the objectives set are achievable within the provided timeframe:-

i. The targeted age of the preschool children is 4-year-old.

The brain development in a child is far more impressionable in early life than in maturity. Vargas-Barón (2005) reported a fact that a child has the excellent learning ability starting from the age of four. Therefore, the proposed GBL framework is aimed at 4-year-old children as this is when brain development of a child begins rapid growth before the window of opportunity is slower down.

ii. The proposed GBL framework is only meant to assist the teachers in teaching and assessing the preschool children in selected preschools.

There are many preschools in Malaysia. The syllabus used in each preschool varies. Nevertheless, the core syllabus of preschools in Malaysia is still based on the Early Childhood Care and Education (ECCE) policy (Brock & Symaco, 2011). In order to evaluate the proposed GBL framework in achieving the objectives set, selected preschools are a must. There are total 16 private preschools that volunteer to take part in this research. The experiment setting comprises control group and experimental group in each preschool for fair evaluation. On the other hands, a survey and an interview are used to collect the feedback from the teachers to evaluate the capacity and ability of the proposed framework in assisting teachers in teaching and assessing preschool children. An intervention program with pre-test and post-test evaluation is used to evaluate the changes in performance of preschool children's learning in terms of language and communication, cognitive, and psychomotor development.

iii. The proposed GBL framework only focuses on three learning areas, which are language and communication, cognitive development and psychomotor development.

ECCE has six essential learning areas – language and communication, cognitive development, socio-emotional development, spiritual and moral development, physical development, and aesthetic and creative development. However, the proposed GBL framework only covers three of these learning areas: language and communication, cognitive development, and physical development.

The foundation of language and communication plays an important role in the cognitive development of a child. Learning a language gives a child the ability to communicate with people and acquire knowledge. Hammer et al. (2014) encouraged the early language and literacy development for future success in learning and academic achievement. Vocabulary learning is the foundation of learning a language and it helps to master a language as well (Carter & Mccarthy, 2014). Vocabulary learning is used for the development of language and communication. This development includes vocabulary and speech development, literacy skills, and communication skills. The scope of vocabulary covers word learning related to body part, colour, shape, and number, as approved and agreed upon by the participated preschools.

Cognitive development involves the development of higher order thinking skills such as reasoning, problem solving, and decision-making skills. These cognitive skills assist a child in exploring the world to which he belongs, and include the understanding of object properties (colour and shape), forming own strategies for solving problems, and making selections among alternative choices. Cognitive development of the proposed system covers decision-making, problem solving and memorising/recognising skills. The participating preschools accepted and agreed on the appropriateness of the aforementioned cognitive skills.

Physical development emphasises developing fundamental motor and psychomotor skills. Fundamental motor skills include those movements of hands and/or legs to perform an action such as body balance, ball catching/throwing skill, push and pull, running, kicking, hopping, and jumping. Psychomotor skills require adequate attention and coordination abilities to perform certain motor skills like catching or throwing a ball from/to a specified target. It is not only the result of stimulation of motor exploration but also arise from children's self-awareness and awareness of the outside world (Hélder José Teixeira Costa, Gómez, Arufe-Giráldez, Couto, & Furelos, 2015). Apart from these, development of various other motor skills supports the control of the body, perform desired movement (dancing), and accomplish daily tasks (open/close door). The scope of psychomotor development covers catch/throw ball skill, body balance skill, jumping, kicking, running, hopping, push and pull as agreed upon and accepted by the participating preschools.

iv. The development and operating platform for the proposed GBL framework is mainly on Microsoft Xbox Kinect.

Due to the time and resource constraints, the socio-emotional development, spiritual and moral development, and aesthetic and creative development are not included.

Socio-emotional development consists of five important domains which are social competence, attachment, emotional competence, self-perceived competence, and temperament/personality (Denham, Wyatt, Bassett, Echeverria, & Knox, 2009). Spiritual and moral development focuses on the development of personality and behaviour regulation through the awareness of self, others, and the environment (Barnes, 2011; Benson, Roehlkepartain, & Rude, 2003). Aesthetic and creative development involves the love of country, and of family, and the pursuit of beauty through the appreciation and learning of art and music (UNESCO, 2011).

These three kinds of development in children require long term observation and guidance from teachers and parents through daily communication and classroom activities. Furthermore, the subjects of interaction involve a large group of people like peers, teachers, neighbours and family members. The cost of development and implementation to simulate a real society could be extremely expensive. In addition, GBL is still facing the technical issue related to analysing kinaesthetic body movement such as facial expressions and body gesture which are essential in evaluating an individual's behaviour, reaction, belief, and emotional state (Schmidt, Laffey, Schmidt, Wang, & Stichter, 2012). Therefore, GBL might not be an appropriate channel for the development and evaluation of these three learning areas.

1.6 Research Contribution

This thesis contributes to the field of GBL in several areas. First, a review of existing teaching and learning approaches are presented. The review analyses the pros and cons of these current approaches as well as the available alternative approach. Besides this, it also contributes to the understanding of the challenge faced by the teacher in integrating GBL into classroom learning. Moreover, the study of GBL frameworks reveals the importance of teacher participation in promoting and facilitating GBL for preschool learning. Furthermore, a theoretical contribution providing insights into approaches such as scaffolding and feedback can be used to foster the transfer of learning for preschool children.

A GBL framework with interactive virtual learning environment (VLE) is proposed and the role of teacher is outlined in the learning process for three primary activities: learning, instruction, and assessment. With the involvement of the teacher in the design process, the proposed system can ensure the appropriateness of content and mapping between learning objective and learning outcomes.

This thesis also contributes to GBL studies through providing empirical evidence and detailed statistical analysis on language and communication, cognitive, and psychomotor development. Besides this, it also encourages the adoption of GBL in preschools and thereby adds to the sparse research that show the inclusion of GBL compared with only a conventional classroom approach produces positive gains. Furthermore, transfer of knowledge can be seen from various game assessments in the proposed system. Finally, the proposed system fosters children learning for both boys and girls and reduces the achievement gap in learning.

1.7 Thesis Structure

This thesis comprises six chapters. The first chapter (Chapter 1) briefly introduces the background of existing relevant research on teaching and learning approaches, and the motivation for research. The problem statement, objective, scope, and contribution of the research are presented as well.

Chapter 2 presents the literature review related to existing GBL framework and issues with the GBL approach. In addition, the technology and implementation platform for GBL are also studied. The age appropriateness of children learning with GBL is reviewed too.

Chapter 3 describes the research methodology for conducting the research. A flow chart is used to explain the flow of research and approaches used to deliver the research objective.

Chapter 4 discusses the proposed GBL framework and the proposed system. The system architecture, system design and implementation of the proposed system are elaborated in detail with illustrations. The function of learning and assessment modules are described using pseudo code and screenshots to provide clear understanding for the learning and assessment activities.

The fifth chapter (Chapter 5) discusses the analysis of results, findings, and implications for the areas of child development, which covers language and communication, cognitive development, and psychomotor skills. The correlation and association between the aforementioned areas of development are presented too.

The conclusions, research contribution, limitations, and areas for future work are presented in the last chapter, Chapter 6. Table 1.1 summarises the entire structure of this thesis.

Table 1.1: Summary of thesis structure

Chapter	Aim and Approach
Chapter 1 Introduction	• Aim: ➢ To briefly introduces the background of existing teaching and learning approaches and motivation of this research. ➢ To discuss problem statement, objective, scope, and research contribution. • Approach: ➢ Discuss the strength and drawback of existing teaching and learning approach. ➢ Explain the problem statement, objective, scope, and research contribution.
Chapter 2 Literature Review	• Aim: ➢ To study existing GBL framework, issues and technology of GBL, age appropriateness for learning GBL. • Approach: ➢ Review and present the related studies for GBL framework, issues and technology of GBL, age appropriateness for learning GBL in an organized structure.
Chapter 3 Research Methodology	• Aim: ➢ To explain the flow of research and approaches used to deliver the research. • Approach: ➢ A flow chart is used to describe the overall flow of research.
Chapter 4 System Design and Implemention	• Aim: ➢ To present the proposed GBL framework. ➢ To give a clear understanding on the system architecture, system design and implementation for the proposed system. • Approach: ➢ Discuss the proposed GBL framework, system architecture, system design and implementation with diagrams
Chapter 5 System Testing and Evaluation	• Aim: ➢ To perform testing for voice and gesture recognition and system integration. ➢ To analyse and compare the statistical results for children's learning performance. • Approach: ➢ Display the screenshots of testing result and explain in brief. ➢ Display the results in tables and graphs together with discussion.
Chapter 6 Conclusion	• Aim: ➢ To summarize the findings and contributions of the research. ➢ To show the limitation of the research. ➢ To set the direction of future study. • Approach: ➢ Discuss the research findings and contributions as well as the limitation and future work.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter reviews the pertinent literature on serious game, game-based learning (GBL), game genre, pedagogy for GBL, existing frameworks, and problems related with the GBL approach. In addition, studies of the technology used to support GBL for teaching and learning are also presented. Moreover, the age appropriateness for children to start learning with GBL is reviewed as well.

2.2 What Are Games?

Games are kinds of leisure activities that come with rules (Caillois & Barash, 1961; Huizinga, 1971) and can be differentiated by representation, interaction, conflict and safety (Crawford, 1984). Also, games can be played cooperatively or competitively and may involve one (physically) to thousands of players (online) (Granic, Lobel, & Engels, 2014).

There are various types of games such as board games, puzzles, and sport games. Games offer the opportunity for players to learn, practice, and improve from their current states of knowledge and skill set. Players communicate, interact, race or compete with each other during the game based on their designated role. They are motivated to improve their judgement, strategy, and skill set to surpass other players or win the game.

In order to progress in a gameplay, a player needs to learn. Fiol and Lyles (1985) defined learning as "*the development of insights, knowledge, and associations between past actions, the effectiveness of those actions, and future actions*". David A Kolb (2014) viewed the learning as "*a process whereby knowledge is created through the transformation of experience*". The player has to learn the rules and required skills or techniques in order to play. In strategy games (i.e. chess), the player learns to plan for every move and bears the consequences of his/her judgements and decisions made. The player improves his/her strategy and plans through accumulated experience and observation in every game. Some games allow for multiple skills development such as cognitive and psychomotor skills. For example, sport games (i.e. swimming) develop not only body coordination and the requisite motor skills but also concentration, persistency, and consistency. To master a sport, the player has to pay continuous effort on learning new techniques and improve through constant practice. Playing games lead to changes in behaviour, knowledge, and skills (Ifenthaler et al., 2012). There exists much research and theories on the use of games to promote learning.

2.2.1 Serious Games

In general, serious games refer to the use of games in learning and instruction (Wouters, Van der Spek, & Van Oostendorp, 2009). Serious games always associate with a serious purpose and can be understood as "*games that do not have entertainment, enjoyment, or fun as their primary purpose*" (Michael & Chen, 2005). Players have to achieve specific learning goals and learning outcomes after playing the games.

Serious games are widely used for the purposes of learning and training such as medical training, military defence, and sports (Crookall, 2010). The focus is given to the fidelity of simulated environment and accuracy of process or effect (Susi, Johannesson, & Backlund, 2007). Simulation games are commonly recommended to meet the above purposes. Besides, it can be used for training that is dangerous, hardly, or expensive to be carried out in reality such as fire drill, terrorist attack, and disaster relief also.

However, serious games are more suitable for adult's training. Without the 'fun' element, children may not engage with the learning easily via serious games. As playing and learning are interrelated, game-based learning (GBL) was introduced.

2.2.2 Game-based Learning (GBL)

Game-based learning (GBL) is a game system that is designed to deliver educational content in various media forms and facilitate the learning process (Anderson, Anderson, & Taylor, 2009). It can be defined as *"putting the games and learning together"* (Prensky, 2005). Besides, it also equip learners with various challenges associated with learning tasks to allow them to experience the game flow while practicing their knowledge and skills (Chen & Law, 2015; Kiili, 2005). Erhel and Jamet (2013) described GBL as a competitive activity where students compete to meet given learning goals by practicing their cognitive skills in a simulated environment.

Based on the literature on games, Ronimus, Kujala, Tolvanen, and Lyytinen (2014) stated that children preferred GBL to traditional classroom learning and had better concentration while engaged in computer-based learning rather than in traditional school tasks. Computer games utilise computer graphics to create a fantasy context for players to work or confront the virtual characters. These features trigger the curiosity and interest of children to encourage them to complete the goals and challenges provided by the games. They are motivated to learn the knowledge, skills, or strategies needed in order to win the game. To have effective learning, active engagement with the learning context is essential (Garris et al., 2002).

In fact, many researchers agree that games can motivate and engage children to learn (Ronimus et al., 2014; Roussou, 2004; Tüzün, Yılmaz-Soylu, Karakuş, İnal, & Kızılkaya, 2009) and perform physical activity or body exercise (Song, Kim, Tenzek, & Lee, 2013; Vernadakis, Papastergiou, Zetou, & Antoniou, 2015b). Motivation is important for encouraging children to participate in learning activities as well as to instil persistence in learning (Campbell & Jane, 2012). It can be categorised as intrinsic motivation and extrinsic motivation. Intrinsic motivation refers to personal enjoyment of or interest in an activity for its own sake (Song et al., 2013) while extrinsic motivation applies whenever an activity is done in order to attain some separable outcome (Ryan & Deci, 2000). Intrinsic motivation can be understood as a person learning because of the challenge, achievement, and/or satisfaction that he/she experiences throughout the learning of a particular topic or skill. In contrast, extrinsic motivation refers to when learners learn due to their personal need or external purpose such as to pass an examination or to gain recognition of a certain standard in their respective fields. Games naturally offer players various challenges, goals and competition. Learning with games seems to be a promising vehicle to enhance both the intrinsic and extrinsic motivations of learning.

Mishra and Foster (2007) discussed how games are related to learning and development in four ways: shaping attitudes, affecting behaviour, influencing understanding, and affecting spatial and motor abilities. They listed 250 distinct claims about games for learning and categorised those effects under five themes: cognitive skills, practical skills, motivation, social skills, and physiological. Undoubtedly, games have a positive impact on learning and development.

The potential of GBL in promoting academic learning has been empirically proven in various fields such as science, mathematics, language studies, and physical education, for knowledge acquisition and skill development. Valerie J. Shute, Ventura, and Ke (2015) and Kim et al. (2009) reported that video games can improve cognitive skills (problem solving and spatial skill). The approach of combining the gesture-based computing technology with GBL proposed by Hsiao and Chen (2016) had successfully improved the learning performance and motor skills of preschool children. Recently, GBL has been used to promote physical activity (Song et al., 2013; Yim & Graham, 2007) and enhance physical education (Staiano & Calvert, 2011; Vernadakis et al., 2015b). In addition, GBL is used to support both formal and informal learning. The research covered learning in preschool (Hsiao & Chen, 2016; Nacher, Garcia-Sanjuan, & Jaen, 2016), primary school (Garcia & Pacheco, 2013; Hainey, Connolly, Boyle, Wilson, & Razak, 2016; Lim, Nonis, & Hedberg, 2006), secondary school (Giannakos, 2013; Hauptman & Cohen, 2011; Vandercruysse et al., 2016) and university (Cheng & Wang, 2011; Fassbender, Richards, Bilgin, Thompson, & Heiden, 2012; Riemer & Schrader, 2015).

After examining the potential and benefits of using games for learning, the next section will introduce game genre and pedagogy of GBL.

2.2.2.1 Game Genre

Genre represents the game design and gameplay of a computer game or video game (Arsenault, 2009). Strategy, role playing, puzzle, sports, simulation, adventure, and fighting are the most popular genre nowadays. Many digital game studies used genre classification as the fundamental concept to discuss, compare and analyse the digital games (Aarseth, 2003; Elliott, Golub, Ream, & Dunlap, 2012; Myers, 1990; Papastergiou, 2009b). Each genre plays different role in learning activities as well as its influence on facilitating learning. For example, simulation game may be more suitable for science education as it allows for experiment and exploration on fundamental concepts. On the other hands, role-playing could be used for behaviour, judgement, and skills development.

Hainey et al. (2016) reported that strategy, puzzle, role-playing, adventure, and simulation were the most popular genre for learning whereas fighting games were rarely been used for children learning. For preschool learning, role-playing, adventure, and sport games are recommended. Role-playing can be used for learning by doing, learning from mistake, adventure games for discovery learning and guided discovery, sports games for skill development, practice and feedback (Rapeepisarn, Wong, Fung, & Khine, 2008). As each genre has its own uniqueness and potential to promote learning, choosing an appropriate genre for GBL is important to ensure effective learning.

2.2.2.2 Pedagogy for GBL

Mortimore (1999) defined pedagogy as any activity that designed to enhance learning. An effective pedagogy can stimulate the learning and improve learning outcome. Different pedagogy has different effect and impact to the learning. Those approaches like instructional, experiential, interactive, narrative, problem-based and exploratory learning are commonly being used for conducting GBL.

However, not all these approaches can be used for preschool learning. For example, problem-based learning expects the learners to build a mental model for a given problem scenario, identified the clues, resources, and tools that can be used to solve the problem and, in the process, learned about the desired learning outcomes (Farrell, Kostkova, Lazareck, & Weerasinghe, 2010). This approach may be more suitable for adults and/or elder children in the field of medicine, science, and engineering as it requires the learners to be independent and has the ability and experience of problem solving. Preschool children may find it too challenging since they are just started to develop their problem solving skill. Similarly, narrative and exploratory learning are popular for primary schools, secondary schools and adults learning as they have higher knowledge level and better collaboration, communication, and decision making skill when compared to preschool children (Ewert, Schuster, Johansson, Schilberg, & Jeschke, 2016; Gamrat, Zimmerman, Dudek, & Peck, 2014; Miller-Day et al., 2015; Turkay, Hoffman, Kinzer, Chantes, & Vicari, 2014).

Preschool children are at the developmental stage and need instruction, demonstration and guidance to learn and practice new knowledge and skills. They also need immediate feedback and correction during their practice. Instructional learning gives sufficient information, explanation, and guidance on the concepts and procedures that are required to learn, including examples, resulted in deeper learning especially for novice learners or those with little prior knowledge (Glogger-Frey, Gaus, & Renkl, 2017; Kirschner, Sweller, & Clark, 2006). Reigeluth (2016) also suggested that instructional learning is effective for them to learn knowledge and skills that required memorization, drill and practice.

Experiential learning encourages the learners to learn and improve through the interaction with surrounding people and environment (David A Kolb, 2014). In this digital era, the gaming technology allows the learners to have virtual interaction with simulated object in a virtual reality environment for learning purposes. They can communicate with virtual characters, manipulate objects to complete a task, and even explore the structure of a molecule. Several researches have shown that experiential GBL could motivate learners and stimulate their willingness to engage in continuous and constant learning (Sung, Hwang, Lin, & Hong, 2017). Besides, this approach also offers an opportunity for learners to learn, practice and explore in a safe and control environment on motor skills (Waite, 2017; Whitton, 2007).

The advancement of gaming technology improves the interaction between player and game system. Interactive approach which takes full advantage of games technology to provide an experiential learning environment for learners to learn, develop and test their knowledge and skill in a virtual reality environment can be used to enhance the children's learning via game (Tang & Hanneghan, 2011). Gesture- and voice-based interactions are the latest interactivity that allows learners to perform a series of tasks, solve problems, and acquire knowledge and skills via body movements and voice command. Besides, this technology can also be used to support individual learning and/or group learning.

After examining the genre and pedagogy for GBL, it is crucial to study existing GBL frameworks and understand how these are used to facilitate learning. The next section will discuss the strengths and weaknesses of each framework.

2.3 GBL Frameworks

Each framework has its strengths and limitations in facilitating GBL. The adoption of pedagogies and game elements may also differ because of the learning objectives and the game theory used. The following section will discuss the existing GBL frameworks: Input-Process-Outcome (IPO) game model, Game Object Model (GOM), Experiential

Gaming Model, Game-based learning framework, Framework for Games in Classroom, and PATIO. The above mentioned frameworks are selected because they are used for teaching and learning purposes. Those frameworks that focus only on the game design and development are excluded.

2.3.1 Input-Process-Outcome (IPO)

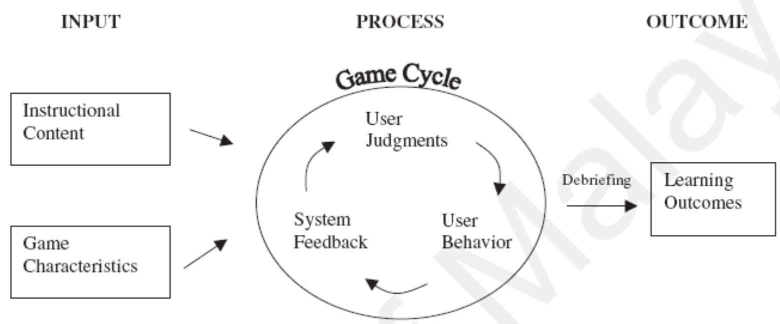


Figure 2.1: Input-Process-Outcome (IPO) game model (Garris et al., 2002)

Input-Process-Outcome (IPO) game model was proposed by Garris et al. (2002). The IPO game model emphasizes the process of engagement that underlies game play in instructional games and learning. The game cycle consists of a repeating cycle of user judgments, behaviour, and system feedback (see Figure 2.1). The pairing of the game features with appropriate instructional content and practice help to achieve desired learning outcomes. However, this pairing is questionable because the model has not aligned it with learning objectives. Van Staalduinen and de Freitas (2011) stated that a good learning experience is much more dependent on the alignment of learning, instruction, and assessment.

2.3.2 Game Object Model (GOM)

GOM was proposed by (Amory & Seagram, 2003) as a theoretical framework for designing educational games by connecting game elements (challenges, narrative, goal, and rules) with educational objectives. GOM consists of a number of important learning areas such as communication, literacy, memory, and motor developments (see Figure 2.2). However, Kiili (2005) analysed GOM as too superficial and designed without consideration for gameplay and flow theory.

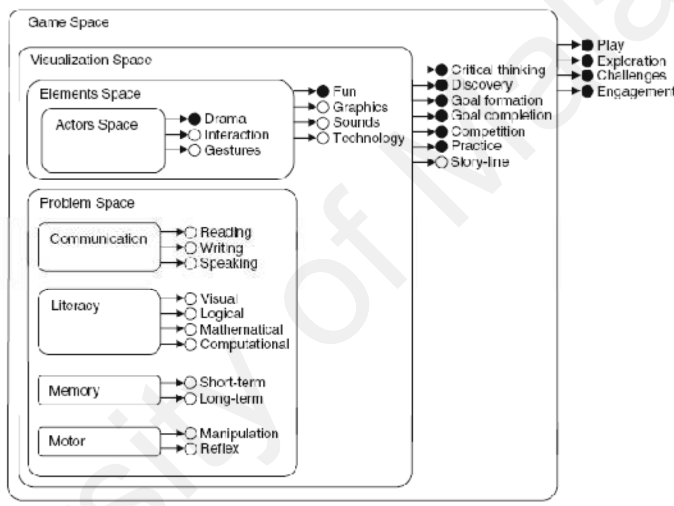


Figure 2.2: Game object model (Amory, 2007)

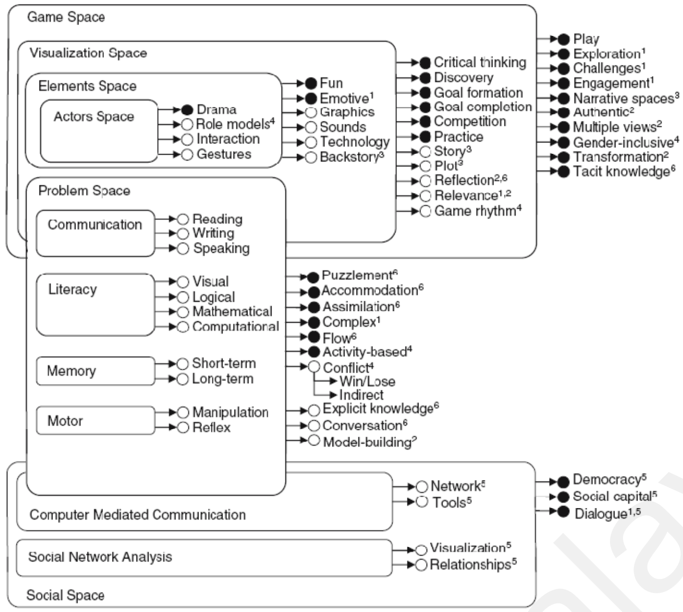


Figure 2.3: Game object model version II (Amory, 2007)

In the year 2007, GOM version II was released, having been revised and enhanced with additional *Social Space* objects to support social interaction through network communication (see Figure 2.3). However, the framework does not provide insights such as learning cycles, feedback, and assistance for learner into the learning process. In addition, this model lacked mapping between learning content and teaching pedagogy.

2.3.3 Experiential Gaming Model

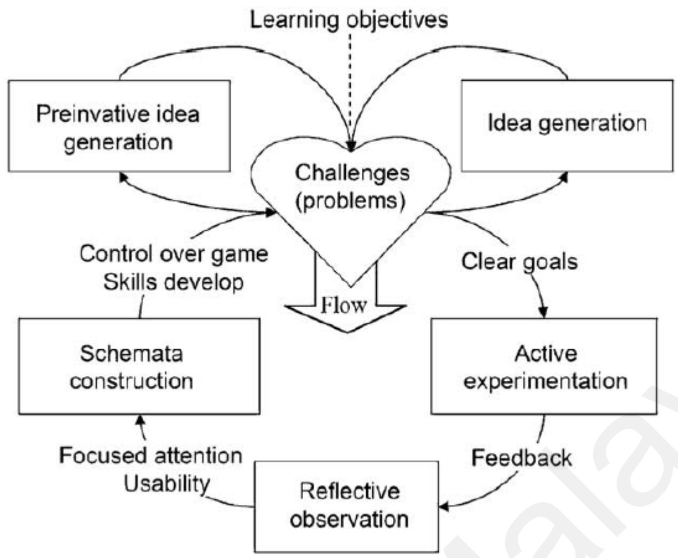


Figure 2.4: Experiential gaming model (Kiili, 2005)

Kiili (2005) proposed an experiential gaming model aimed at linking gameplay with experiential learning in order to facilitate flow experience as depicted in Figure 2.4. Flow experience refers to optimal experience when engaged in an activity (Van Staalduinen & de Freitas, 2011). This gaming model was useful for designing and studying educational games and gaming in general (Van Staalduinen & de Freitas, 2011).

In fact, this model promotes individual learning and does not cover social interaction. Kiili (2005) defined learning as "a construction of cognitive structures through action or practice in the game world". This definition violates the theory of the zone of proximal development where "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers" (Vygotsky, 1987). What this means is that learning, either the development of skills or knowledge acquisition, requires interaction such as play, physical contact, or collaboration with the surrounding people. “Games work best when coupled with effective pedagogy” (McClarty et al., 2012). With appropriate guidance or instruction, a game can assist players in coping with problems and reduce the frustration caused by failures in problem solving (Gee, 2003; McClarty et al., 2012).

2.3.4 Game-based Learning Framework

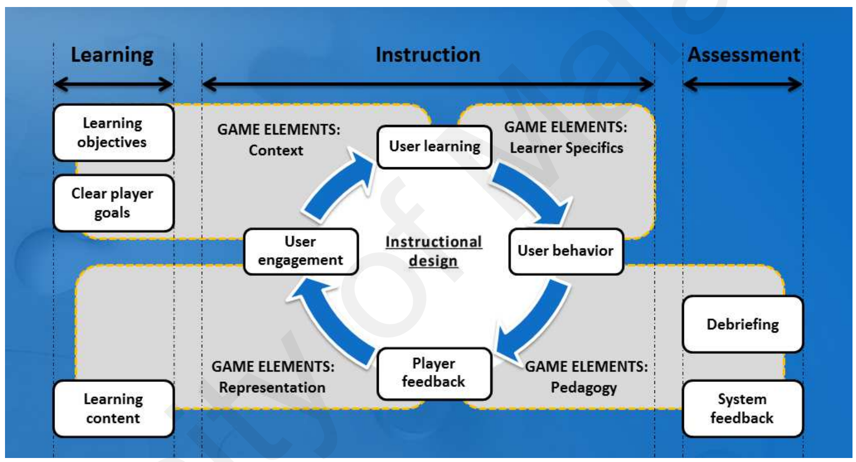


Figure 2.5: Game-based learning framework (Van Staalduinen & de Freitas, 2011)

Van Staalduinen and de Freitas (2011) proposed a game-based learning (GBL) framework based on previous work in four-dimensional framework (De Freitas & Oliver, 2006) and serious-games design framework (De Freitas & Jarvis, 2009), which both adapt the instructional and cognitive approaches into the design process. The game-based learning (GBL) framework focuses on four important categories: learner modelling and profiling, pedagogic approaches for supporting learning, the representation of the game itself, and the context within which learning takes place (De Freitas & Oliver, 2006). It covers three important areas of the learning process, which are learning, instruction, and assessment, as shown in Figure 2.5. The learning column covers learning objectives, player goals, and learning content. For the instruction column, the aforementioned game elements (learner specifics, pedagogy, representation, and context) are incorporated into the instructional approach for the game design, to enhance the individual or group learning. Lastly, the assessment column can be either debriefing (informal assessment) or system feedback (in-game assessment), or both.

This framework is effective in designing, selecting, facilitating, and evaluating the educational game for learning purposes. Students have the ability to choose and decide what to learn and what to play. However, the framework required modification if used for preschool children due to the minimal amount of instruction given. Preschool children need proper instructions and guidance from adults such as teachers and parents in order to learn and practice their knowledge and skills in an appropriate context. It is not intended that GBL replace teachers and classrooms but textbooks and science laboratories (Steinkuehler & Chmiel, 2006). Therefore, teachers play an important role in the learning framework especially for preschool children.

2.3.5 A Framework for Games in Classroom

Sadler, Romine, Menon, Ferdig, and Annetta (2015) had proposed a framework for games in the classroom by focusing on the role of the teacher in interpreting curricular material (see Figure 2.6). Besides providing opportunities for students to engage with the game and other learning materials, the framework also manage the classroom time, assessment data, and other aspects that could influence student learning. Unfortunately, this framework provided no evidence that the results of a student learning with a game could exceed those of a student learning in a non-game curriculum with similar content focus. The author argued that highly prepared and qualified educators can deliver the learning content better than technology-based game curriculum. Although motivation is key to engage the learner in learning, effective learning also requires the support of instructional strategy (Wouters & van Oostendorp, 2013), quality content, and meaningful context (McClarty et al., 2012).

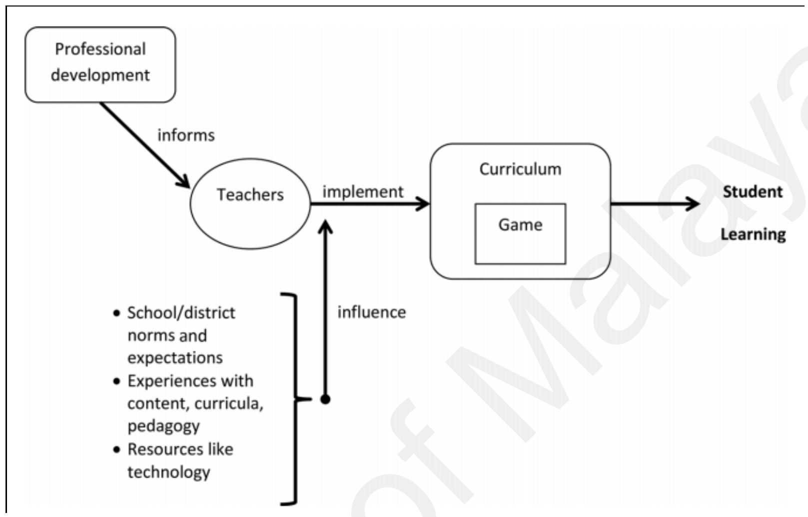


Figure 2.6: A framework for games in classroom (Sadler et al., 2015)

2.3.6 PATIO

Fernández-Molina et al. (2015) proposed a generic computer-based learning framework, namely PATIO, for early childhood education. This framework aimed to improve pre-schoolers' cognitive development in the areas of attentional control and working memory through computer games and activities. It contains a set of tools for defining (Authoring tool), delivering (Learning tools), assessing (Assessment tool), and monitoring (Monitoring tool) learning activities.

PATIO organises the preschool curriculum into the contexts that children are familiar with as well as the topics to be learned. The designed learning activities focus on the training of visual perception, spatial orientation, memory, and attention skills. Teachers act as facilitators and they are not allowed to help the children or give any instructions during the training as well as the assessment. However, this framework is limited for cognitive skills development and focuses only on individual learning.

2.3.7 Comparison of Framework

Table 2.1 compares the reviewed frameworks in terms of learning objective, instruction, assessment, and teacher involvement. The comparison of the frameworks eases the understanding and selection of the GBL framework for preschool learning.

Hsiao and Chen (2016) used IPO for preschool children learning. They developed the game and assessment activities by combining the instructional content and learning process with the game characteristics (fantasy, rule/goal, sensory stimuli, challenge, mystery, and control). However, the scope of learning was restricted to colour recognition and ball catching skills. In addition, all the selected participants were required to have computer-based learning experience and familiarity with GBL. Therefore, it is hard to conclude that IPO is suitable for novice learners, especially pre-schoolers without teacher guidance and support.

The studies in GOM covered a wide range of game genres for educational games. However, the teacher's role and the pedagogy used for learning are not discussed. GOM is only suitable for use as a reference for developing games instead of designing and evaluating game systems. On the other hand, Experiential Gaming Model focuses on players' flow experience to engage the players with learning. This model is suitable for designing and promoting exploration learning such as in science and mathematics.

Nevertheless, it does not cover social learning and is not suitable for instructional learning such as in language learning and development/mastery of motor skills.

Table 2.1: Summary of reviewed GBL framework

	IPO	GOM	Experiential Gaming Model	GBL Framework	Framework for Games in Classroom	PATIO
Learning objective		✓	✓	✓	✓	✓
Instruction	✓	✓*	✓	✓	✓	✓
Assessment	✓		✓	✓		✓
Teacher involvement				✓*	✓*	

**partially involved*

The game-based learning framework offers a good model for educators and researchers to design or adopt educational games for learning purpose. However, it targets primary, secondary, and undergraduate students since less instructional guidance is given. Teachers act as the implementers in this model. Nonetheless, the involvement of teachers should extend to content preparation and strategy delivery because highly prepared and qualified educators can deliver the learning content better than the GBL approach (Sadler et al., 2015).

Lastly, PATIO is a computer-based learning framework for early childhood education. This framework is restricted to promoting pre-schoolers' cognitive development through computer games and activities. Again, teachers act as facilitators and they are not allowed to help children or give any instruction during the training as well as during the assessment. Furthermore, this framework does not support group learning, discussion, and interaction.

The role of teachers in the teaching/learning process cannot be replaced by technology especially when educating children. Young children usually start learning with their family members. When they are sent to formal schooling, they learn from school teachers. Apart from teaching academic content and character building, teachers also give help and support to children when they encounter problems in their learning, problems in communicating with peers and problems in motor skill development.

Teachers are always the key for successful integration of GBL in classroom learning. They take the lead to introduce, learn, and keep up to date with the new technology and media. Through their guidance, technology phobia can be minimised and children can be easily adapted to the advanced and complex societies. Furthermore, teachers can also encourage the children to use the GBL for entertainment, practice, and revision purposes besides learning. Therefore, teachers play an essential role in GBL for preschool learning because they have an indelible influence during a child's schooling experience.

2.4 Barriers for Teacher's Adoption of GBL

GBL has been discussed for a decade now, because of its potential and benefit in facilitating learning. However, it is still not yet a common teaching and learning approach in Malaysia's formal school education, especially in preschool curriculum. Teacher adoption of GBL is the key for the implementation of GBL in preschool learning. However, barriers to integration of classroom learning with GBL exist for teachers. There are three orders of barriers which are first-order (external), second-order (internal), and third-order (lack of design thinking by teachers) (Tsai & Chai, 2012).

2.4.1 First–order Barrier

Ertmer (1999) listed out the external factor such as lack of access to computers and software, insufficient time to plan instruction, and inadequate technical and administrative support as the first-order barrier for integrating technology to the classroom learning.

In Malaysia, teachers are responsible for the preparation and adoption of games in classroom learning (Latif, 2014). Additional time is needed to be spent for the preparation of game lessons (Bauer & Kenton, 2005). The preparation includes integrating the learning content with game activities, time allocation for game lessons, and also the training or guidance of students' learning of the game. Before a game is selected for classroom learning, the teacher has to learn the game first and then verify the relevance of the game's content with the school curriculum. If the game is relevant to student learning, he/she needs to plan the time that can be allocated for game lessons without affecting normal class lessons. Besides this, student training time has to be taken into consideration too. Most of the teachers were not willing to conduct GBL in school because of the extra time needed for preparation of the lesson and also for guiding students.

Another challenge for teacher to use games for classroom learning is technical support (Bourgonjon et al., 2013). Teaching with technology requires teachers to have technical knowledge sufficient for handling hardware and software issues that occur during the lesson (Wachira & Keengwe, 2010). Besides, administrative support such as facilities, access to computer and software, and resource sharing are also the concern of promoting the use of technology in teaching and learning process.

2.4.2 Second–order Barrier

The second-order barrier refers to the teachers' belief about teaching and technology, established classroom practices, and unwillingness to change (Ertmer, 1999). As explained in the previous section, teachers may not be equipped with sufficient technical knowledge to implement GBL in classroom. Failure to give adequate support to students during the lesson reduces confidence in the use of games for teaching and learning.

Technical support training for teachers who are to conduct GBL in classrooms may help them overcome their inhibitions and lack of knowledge (Ketelhut & Schifter, 2011). Therefore, they may require more time for practice and also to develop an interest in and knowledge of the games as part of the process of preparing game lessons (Ketelhut & Schifter, 2011). In addition, it may also encourage the change in teachers' acceptance of technology integration.

2.4.3 Third–order Barrier

Tsai and Chai (2012) suggested the third-order barrier should be the lack of design thinking by teachers. Tsai and Chai explained that the challenge from varying learners' need and dynamic classroom context could be resolved through designing and organising the learning material and activities by incorporating the right pedagogy and technology integration.

A teacher has to understand and learn the game before he/she can teach with the game. Insufficient knowledge prevents teachers from exploring a game and studying its potential for learning. Li and Huang (2016) investigated teachers' acceptance of GBL through the perspective of their experiences with video games. The findings showed that the level of familiarity with video games could affect teacher adoption of GBL. Unfamiliarity to a game can lead to discomfort and anxiety in case of failure in the design, implementation and adoption of GBL (Ketelhut & Schifter, 2011). Ucus (2015) also reported his findings on teachers' viewpoints regarding the difficulty of using games for evaluation due to insufficient knowledge of GBL. Ketelhut and Schifter (2011) suggested that more time should be given to the teachers for evaluating the use of GBL technology in classroom and how it is to be used to engage the student for learning and achieve the desired learning goals. In addition, teachers can also increase their acceptance of the technology and also, the perceived usefulness of GBL for teaching and learning (Scherer, Siddiq, & Teo, 2015).

Bourgonjon et al. (2013) also emphasised that familiarity of games by the teacher was important for reducing reluctance in exploring and learning a game due to the complication and complexity of gaming technology. Besides, unfamiliarity with games can also affect a teacher's decision in choosing, planning, and designing the right game to support the curriculum and classroom learning. Various support measures such as training, involvement of teachers in game design and implementation, and student feedback and evaluation, should be given to teachers to make them familiar with teaching in a gaming environment and encourage their adoption of GBL for classroom learning (Emin-Martinez & Ney, 2013).

2.4.4 Malaysia government's effort for preschool education

Since the year 2009, Ministry of Education (MOE) has actively engaged in the effort on providing quality and affordable preschool education for nationwide by listing it as one of the five sub-NKRAs (National Key Result Area) in education. PERMATA Programmes were founded to take care of the development of Early Childhood Care and Education (ECCE).

Kindergarten teachers face great challenges in handling the diversity of children's communication languages, learning style and experience (Keels & Raver, 2009). Different family and social backgrounds also cause the gap in learning progress and the social interaction between peers. To overcome the divergence in early childhood policy and education program, standard based curriculum was implemented to ensure all children receive equal and high equality of education (Department_of_Malaysian_Studies, 2010).

The government allocated RM 10 thousand as an incentive for those private preschool providers to set up a new preschool. At the same time, government primary schools will also prepare for the preschool program as planned. Great attention is paid to child education because the Malaysia government believes that it can resolve the human capital issue and it is also the right strategy to realise Vision 2020.

The annual changes in information technology bring great impact to the education. The 2016 PERMATA International Conference was held to discuss the preparation of children for sustainable nation building and world peace (PERMATA_Division, 2016). Integration of technology with education was one of the concerns for the conference. With proper early education and care program, children from disadvantage family could have better achievement than their more advantage peer (Burger, 2010). Appropriate use of technology can bridge the gap of poverty and culture by offering an equal opportunity of learning to all the Malaysian children. The integration of GBL in classroom learning can ease the delivery of knowledge and enhance the learning experience. Furthermore, the differences causes by social economic status, family education attainment, culture and language can be minimized via carefully content design and learning approach.

2.5 Transfer of Knowledge

In general, transfer of knowledge refers to how the knowledge or skill is being applied in varied contexts. There are two types of transfer: near transfer (transfer to similar context) and far transfer (transfer to different context). Based on the taxonomy of far transfer, the investigation of transfer can be analysed through the dimension of content (learned skill, performance change, and memory demands) and context (knowledge domain, physical context, temporal context, functional context, social context and modality) (Barnett & Ceci, 2002). The details and example of the taxonomy of far transfer are shown in Table 2.2.

From the perspective of content, transfer of knowledge can be observed via learned skill, performance change, and memory demands. In relation to learned skill, this can range from being specific in the sense of its being a routinized procedure or a particular fact, or general in being a non-specific problem-solving skills or principle (Barnett & Ceci, 2002). Procedure learning is associated with psychomotor skills development because it requires sequential steps to be learned in order to perform an act (running), a process (washing clothes), or a routine (login to a system). Representation learning can be understood as the learning related to an illustration or a matrix that uses memory together with visual and spatial skills. The schematic diagram for designing or building an electronic circuit, array and vector computation as well as Venn diagrams are examples of representation learning. The principle or heuristic transfer is related with cognitive skill development such as problem solving, planning, and programming skill.

Table 2.2: Taxonomy of far transfer (Barnett & Ceci, 2002)

Content: What transferred			
Learned skill	Procedure	Representation	Principle or heuristic
Performance change	Speed	Accuracy	Approach
Memory demands	Execute only	Recognise and execute	Recall, recognise, and execute

Context: When and where transferred from and to					
	Near ←				→ Far
Knowledge domain	Mouse vs. rat	Biology vs. botany	Biology vs. economic	Science vs. history	Science vs. art
Physical context	Same room at school	Different room at school	School vs. research lab	School vs. home	School vs. the beach
Temporal context	Same session	Next day	Weeks later	Months later	Years later
Functional context	Both clearly academic	Both academic but one non-evaluative	Academic vs. filling in tax forms	Academic vs. informal questionnaire	Academic vs. at play
Social context	Both individual	Individual vs. pair	Individual vs. small group	Individual vs. large group	Individual vs. society
Modality	Both written, same format	Both written, multiple choice vs. essay	Book learning vs. oral exam	Lecture vs. wine tasting	Lecture vs. wood carving

The measurement of performance change focused on speed, accuracy, and approach (Barnett & Ceci, 2002). Speed refers to the time taken to complete a task, give a response, or solve a problem. The improvement in precision of an action or quality of a job was measured as accuracy. The transfer of knowledge can also be evaluated through the strategy and solution used in completing a task or handling an issue.

The context of transfer is crucial for evaluating the degree of transfer (near and far). Barnett and Ceci (2002) identified six types of contexts used to measure knowledge transfer: knowledge domain, physical context, temporal context, functional context, social context, and modality. In brief, knowledge transfer can be measured through the application domain (knowledge domain), place or location (physical context), duration of time between training and testing (temporal context), differences between the original purpose of learning and the applying purpose (functional context), individual performance and group participation (social context), and way of expressing, demonstrating or applying the knowledge and skill (modality). Based on these six contexts, the evaluator can understand how far knowledge is transferred, in what situation, as well as when and where it takes place.

Knowledge transfer can be seen through complex cognitive skills (e.g. problem solving, decision-making, memory or recall of past incident) (Szulanski, 2000) as well as psychomotor skill (Aggarwal, Grantcharov, Moorthy, Hance, & Darzi, 2006; Lehmann et al., 2005). However, concerns relating to adopting GBL as an effective learning tool have been raised due to the validity of assessments used in games (Johnson, Reisslein, & Reisslein, 2015). One of the concerns was the measure of knowledge transfer (Bellotti, Kapralos, Lee, Moreno-Ger, & Berta, 2013). After understanding the characteristics of transfer, the taxonomy of far transfer is useful and should be used as a reference when designing an assessment and evaluating student learning outcomes (Barnett & Ceci, 2002).

The transfer of knowledge can easily take place or happen when the learning context is similar to the applied context (Ganea, Pickard, & DeLoache, 2008). Besides, scaffolding and feedback (e.g. debriefing and assessment) can promote knowledge transfer and the mechanisms underlying the transfer process (Alklind Taylor, 2014; Barnett & Ceci, 2002). The coming sections will discuss the learning context, scaffolding, and feedback in assisting learning.

2.5.1 Virtual Learning Environment for GBL

"*Water affords breathing for a fish, but not for a human. A chair affords sitting for an adult, but not for an infant…….*" (Linderoth & Bennerstedt, 2007). Linderoth (2012) used affordance to explain the interaction offered within a learning context; learning only occurred when the affordances were perceived and utilised. In other words, if a learning context (game environment) is not properly designed to specifically facilitate learning, players are unlikely to learn anything beyond the manipulation of game mechanics. There are two types of learning contexts, fantastical and realistic.

Fantasy is one of the features of computer game that offers a virtual reality world for a player to fulfil his/her imagination. In a fantasy context, the player can role play a virtual avatar (i.e. monster, hero, spirit, and etc.) before starting his/her adventure journey. The player can interact with other virtual characters (role played by other players), form a team or fight against each other to win the glory. In addition, the challenge, fantasy storyline, and multimedia presentation immerse players immerse into the game so that they continue to play the game. The engagement with the fantasy world has increased the interest of researchers to enhance learning via fantastical context (Asgari & Kaufman, 2004; Gunter et al., 2008; Malone & Lepper, 1987).

However, although the use of fantastical context may contribute to far transfer, it may not suitable for child's learning (Subrahmanyam et al., 2001). Richert et al. (2009) questioned how the fantastical context can convey real world information to children because there is a gap between what they learn and reality.

A realistic context can present the scenarios and objects of real world through simulation. Besides, realistic context facilitates the development of problem solving skills and improvement in the understanding of complex concepts in a GBL environment (Liu, Cheng, & Huang, 2011). The findings by Richert and Smith (2011) supported the above, arguing that realistic context (use of real characters) is more effective in assisting children to apply the problem solutions taught by human characters compared to fantasy characters. Therefore, to ease the delivery of knowledge, realistic or authentic context with real characters is recommended as the learning context for preschool learning.

The ultimate goal of learning is to promote the transfer of knowledge in different contexts. The use of realistic context in GBL could be a possible solution for realizing this goal in preschool learning. For preschool children, realistic context can be more effective in facilitating learning by helping them to connect the knowledge to reality. Besides, it may improve their retention of knowledge and encourage knowledge transfer due to familiarity. Therefore, further investigation of the use of realistic context in GBL for preschool children is essential.

"Learning is the process whereby knowledge is created through the transformation of experience" (Kolb, 1984). From the experiential perspective, learning is a cycle begins with personal involvement in a specific experience (concrete experience), then the learner reflects the experience from many viewpoints (reflective observation) and draws logical conclusion (abstract conceptualisation) for his action and decisions (active experimentation) and lead him to new concrete experience (Svinicki & Dixon, 1987). GBL promotes experiential learning when the preschool children interact with the system.

The preschool children act as actor (active involvement) than a receiver (passive involvement) in GBL when compared to classroom learning. Book and whiteboard restrict the interaction between children and the topic/knowledge to be learnt. The children are passively receiving the knowledge delivered from the teacher and source of learning materials. In contrast, GBL establishes a VLE for children to explore, interact, and manipulate. They may communicate with the system via voice and gesture interaction (concrete experience). They obtain their knowledge and skill through practices and interaction with the system (reflective observation) and improve their understanding and skill (abstract conceptualisation) through trial-and-error and problem solving (active experimentation). The active involvement with the system leads them to have a new kind of learning experience.

2.5.2 Scaffolding

Wood, Bruner, and Ross (1976) defined scaffolding as a kind of assistance given by an adult (teacher or parent) to support a child or novice in task completion, problem solving, or accomplishing a target that is beyond his/her knowledge or capability. The advancement of technology allows scaffolding to be embedded into digital learning system. Kim and Hannafin (2011) coined the technology-enhanced scaffolding as "*cognitive and social supports designed to augment student problem-solving inquiry*".

Many GBL studies chose to use technology-enhanced scaffolding (Barzilai & Blau, 2014; Demetriadis et al., 2008; Huang & Huang, 2015; Sun et al., 2011). However, the drawbacks are that students may become reliant on the support given and thereby have reduced learning opportunities (Sun et al., 2011) as well as lowered memory retention of learned content (Huang & Huang, 2015).

Technology-enhanced scaffolding includes providing visual aids and demonstrations to support students in learning (Belland, 2017). Visual aids have long been used to support classroom learning and proven to be an effective approach to improve the student comprehension. Mayer and Moreno (2002) stated that meaningful learning can only take place when a student can establish a connection between visual and verbal representations. On the other hand, demonstration is a reliable approach for facilitating the learning of motor skills. The findings reported by Vernadakis, Papastergiou, Zetou, and Antoniou (2015a) are in line with the above claim that demonstration improves children's motor skills. Further investigation of the use of visual aids and demonstration in preschool GBL, in particular, in which context, when it should be used and the form of presentation can give better evidence of the effectiveness of technology-enhanced scaffolding in assisting pre-schoolers' learning.

2.5.3 Feedback

Feedback gives information about the current learning progress of a student towards the topic learned (Nicol & Macfarlane - Dick, 2006). Feedback can be categorised as internal (self-evaluation) or external (i.e. teacher or system) (Brookhart, 2008). It can be presented in various modalities such as in the written form and as oral communication. For preschool learning, internal feedback is not suitable because the young children do not yet have the ability to perform self-evaluation. Therefore, the focus of discussion is on external feedback. In GBL, system feedback and game assessment can be used to inform the student of how his/her present state of learning aligns with the learning goals.

The two common types of system feedback used in GBL are corrective feedback and explanatory feedback (Erhel & Jamet, 2013). Corrective feedback directly notifies the student whether the given response/answer is correct or incorrect. On the other hand, explanatory feedback is more informative as it provides explanation and justification for the correct answer/response to the student.

According to Moreno and Mayer (2007), students learn better with explanatory feedback rather than corrective feedback. Yet, the effectiveness of corrective feedback in facilitating learning that was found is questionable due to limited information provided (Tsai et al., 2015). Furthermore, the effectiveness of feedback depends on the topic of learning and the target (student) who is receiving the feedback. For example, science and mathematics subjects always measure knowledge transfer through problem solving. Explanatory feedback will be more effective in explaining the nature of problem, analysing, and suggesting possible solutions. Students can improve their answer or solution based on the feedback given. Nonetheless, if the explanation is too lengthy or not specific enough to allow the students to find out their mistake or problem in their solution, the feedback given is useless and ends in uncertainty and confusion (Valerie J Shute, 2008). Moreover, the students may be discouraged to process the information embedded in a lengthy or complicated feedback, resulting in non-effective learning.

According to Espinet et al. (2013), corrective feedback is essential in engaging preschool children to learn effectively because it is straightforward and simple. In addition, corrective feedback is more effective than explanatory feedback in informing a student of a mistake made, instantly in the case of practice or skill training (e.g. pronunciation and motor skill development) (Hsiao & Chen, 2016; Muis et al., 2015). It is worth it to examine the use of corrective feedback for preschool GBL.

Assessment is a judgment regarding how well a student's performance matches the intended learning outcomes for a given subject or topic (Stefani, 2004). Formative and summative assessments are common evaluation method adopted by formal education and public school system. Formative assessment reflects the student learning progress from time to time via informal test such as "pop quiz" whereas summative assessment is a formal evaluation that used to assess the student performance at the end of semester, a unit or a course (Valerie J Shute & Kim, 2014). Formative assessment can instantly give feedback to student on current topic and assist the teacher to adjust his instructional pedagogy. In contrast, summative assessment reflects only the overall performance of learning and gives very little support to the teachers in the learning process. The benefits of the aforementioned assessment include: (a) the assessment result is accountable for the measurement of student's knowledge, skills and abilities; (b) comparison and analysis can be make based on student performance and background (Valerie J Shute & Kim, 2014).

However, they have several drawbacks. First, students may focus on the topic to be assessed resulting in inappropriate learning attitudes and rote memorisation (Gibbs et al., 2005). Besides, these kinds of assessment hardly provides evidence on knowledge transfer and gains in learning (Bellotti et al., 2013). In contrast, game assessments can evaluate the ability of students to transfer knowledge learned through games and to solve novel problems, neither of which is traditionally assessed (Klopfer, Osterweil, & Salen, 2009).

The use of game assessment is not yet popular in formal education, mostly only being accepted as secondary evaluation or informal assessment. Some GBL scholars like Kebritchi, Hirumi, and Bai (2010) used the school assessment to evaluate student academic achievement to highlight the positive effects of games on learning in formal school settings. In fact, game assessment allows for a wider scope of evaluation not only covering subject knowledge but also cognitive (e.g. problem solving) and psychomotor (e.g. hand-eye coordination) skills (Valerie J Shute & Ke, 2012). Furthermore, adequate and immediate system feedback given to students along with the game assessment is very helpful as it facilitates the development of mental models and schemata and thus improves expertise and expert performance (Ifenthaler et al., 2012). Students are more engaged with game assessment when compared to formal assessment due to the authentic gaming environment (Wood, Teräs, & Reiners, 2013).

However, the adoption of game assessment relies on teacher acceptance. Unfamiliarity and lack of technological knowledge with the game becomes an obstacle to the incorporation of game assessment in the classroom, as teacher having difficulty handling the overly-complicated technology (Kenny & McDaniel, 2011). Effective and continuous training is essential in helping teachers to be familiar with GBL as well as to encourage the incorporation of game assessment with classroom learning. The training also ensures that the teacher can effectively assess the student's actual learning progress and outcomes.

Table 2.3 summarises the strengths and limitations of the aforementioned types of feedbacks. Based on the analysis in Table 2.3, the proposed learning system will use corrective feedback to inform the preschool student of his/her mistake as it is straight forward and requires less effort to process the message given. For student evaluation, game assessment will be adopted to engage the preschool children in assessment activities and at the same time examine knowledge transfer in a more comprehensive manner.

Table 2.3: The analysis of feedbacks for GBL

	System Feedback		**Assessment**		
	Corrective	**Explanatory**	**Formative Assessment**	**Summative Assessment**	**Game Assessment**
Strength	• Simple and straight forward • Less processing time	• Detailed elaboration and explanation for the problem given • Areas that require further improvement identified	• Simple and time saving • Reflects student progress in timely manner	• Accountable for the measurement of student's knowledge, skills and abilities	• More comprehensive and better judgement on student progress can be made • More engaging
Limitation	• Lack of detailed explanation of mistake or incorrect action	• Too lengthy • Too complicated to understand • May not be specific and useful	• Scope of assessment limited to subject matter knowledge • Boredom	• Scope of assessment limited to subject matter knowledge • Infrequent	• Teacher is required to have technological knowledge
Suitability for preschool learning	• Suitable	• Not suitable	• Not suitable	• Partially suitable	• Suitable

2.6 Learning Content

Malaysia is one of the Member States of United Nations Educational, Scientific and Cultural Organization (UNESCO) and the principle of national preschool education is based on the ECCE policy (Brock & Symaco, 2011). In the UNESCO report, six essential learning areas are identified: language and communication, cognitive development, socio-emotional development, spiritual and moral development, physical development, and aesthetic and creative development. The preschool's curriculum follows the primary principle defined by ECCE, which aimed on helping the children to develop critical thinking skills through enquiry and the use of all the senses, practice good health and safety measures by exploring them to an interactive and stimulating environment language (MOE, 2007).

ECCE refers to a wide range of preschool programs with a general goal to promote the development of children on cognitive, physical, and social perspective (Mishra, 2009). The design of ECCE program has to incorporate the value, culture, and religion of a country (Vargas-Barón, 2005). Therefore, the implementation of each ECCE program varies with curriculum design, teacher quality, and infrastructure. However, literacy and numeracy skills, which play essential role in cognitive development, still are the ultimate goal for all the ECCE learning frameworks and emphasized in every ECCE program (Rose, 2014).

The contribution of GBL in the areas of learning in personal and social development, language and literacy, mathematical development, creative development, knowledge and understanding of the world and physical development have been explored (McFarlane et al., 2002). In the aforementioned areas, developments have allowed associated cognitive (i.e. problem solving and spatial skills) and psychomotor skills (i.e.

body coordination and object control skills) to be learned, practiced, and enhanced as well (Staiano & Calvert, 2011; Vernadakis et al., 2015b).

"If the school curriculum covers too much, fails to consider pupils' initial learning levels and teachers' ability to deliver, or moves too fast, then pupils will fall behind and stay behind. If the pace at which the curriculum is taught is too fast for most learners, this can result in a large proportion of children learning very little as they progress through school grades"

(Pritchett & Beatty, 2012)

When preparing the learning content for GBL system, great attention has to be paid to the scope and the pace of learning. In addition, the appropriateness of content can also affect motivation of learning. Research promoting vocabulary learning in a gaming context conducted by Sandberg et al. (2014) showed that even when the child participants were not interested in the learning material because the target words (learning materials) were difficult for them to understand, they had better performance during the subsequent vocabulary test. In their study on the suitability of computer games for cognitive training, Martinovic et al. (2016) also highlighted that children had trouble understanding games that consist of unsuitable levels of challenge. To assure appropriateness in learning content, a proper investigation into children's level of knowledge and skills as well as their development stage. This is essenital to avoid the demotivation and frustration along the learning.

2.6.1 Language and Communication

Language is defined as "the method of human communication, either spoken or written, consisting of the use of words in a structured and conventional way" (language, 2015). Nowadays, language use is no longer limited to communication, but is also used for religion, education, and psychology purposes. The learning and use of a language is consolidated in the knowledge of literacy, which comprises reading and writing (Hoff, 2013). Literacy knowledge is developed through vocabulary acquisition and is improved by increasing vocabulary size and ability (Barone & Morrow, 2003). Therefore, vocabulary learning is the foundation of learning a language and it helps to master a language as well (Carter & Mccarthy, 2014).

The early social lives of children begins with simple expression (e.g. smile) and communication (e.g. hello) between peers and familiar adults such as teachers and neighbours. Children also start building up their personalities based on day-to-day observations and social experiences with people they meet every day. Language and communication development can help children to develop their speech and vocabulary to use in their daily communication (Buckley, 2012). This development includes vocabulary, pronunciation (speech), and communication skill development.

Early language development always starts with reading as this is an essential skill for translating visual codes (vocabulary) into meaningful language (Whitehurst & Lonigan, 1998). One of the ways to develop effective reading (pronunciation/speech) skills is to link vocabulary with semantic representation. Let's take the word "bee" as an example. The logical connection between word and object can be formed easily if a child knows what a bee is or it looks like. Otherwise, "bee" is meaningless to the child and increases the difficulty of remembering and recognising the word.

There are many ways a child can obtain knowledge and develop understanding in his/her personal world. For example, the observation of weather will help a child to understand how a change in weather affects routine activities. He/she will know that no outdoor game is allowed during the rainy day while a windy day is suitable for playing kite. The learning of vocabulary can begin with familiar objects or the surrounding environment such as body parts (Greenberg, Ferguson, & Moravcsik, 1978), colours (Carey, 1978), shapes (Rieben & Perfetti, 2013), and numbers (Coplan, Barber, & Lagacé-Séguin, 1999). The use and understanding of language can be improved over time when children interact with the objects and people around them.

Beginning with the human body structure, the learning content can be grouped from body parts and extend to human sensory system and further into anatomy systems such as the skeletal system, digestive systems, and cardiovascular system. As there is no fixed syllabus for teaching body parts, adjustments to the content are made to ensure learning is appropriate and effective for a 4 year old child. A human being has five senses, which are sight, hearing, smell, taste, and touch. These five senses belong to specific organs: eye - sight, ear - hearing, nose - smell, tongue - taste, and hand - touch. All these senses are very important to a human being; they need them to recognise their surroundings and estimate distance, communicate, develop a sense of danger, enjoy food, and do work. For a child, these senses help him/her to explore the world around them and learn to control the body to give right responses and perform daily activities. Thus, it is essential for a child to learn about the organs that directly control the five senses.

Children start to learn body parts from common parts and then move on to more specific parts. The common parts selected are hair, head, eye, ear, nose, mouth, tongue, teeth, body, hand, finger, and leg. Children under the age of seven may not have the ability to recognise detailed or tiny parts of the body like the nostril, forehead, chin, eyebrows, eyelids, eyelashes, and nails (Pica, 2008). Therefore, detailed parts of the body are excluded. The final list of body parts selected for the proposed framework are *Hair, Head, Eye, Nose, Ear, Mouth, Tongue, Teeth, Body, Leg, Hand, and Finger*. Nevertheless, further investigation of the list of body parts is required to ensure the appropriateness of learning content for Malaysian preschool education.

When children start exploring the world around them, they will feel curious about the appearance (i.e. colours and shapes) of an object. For example, a lemon is yellow in colour and appears to have an oval shape, while a star fruit is green in colour but has a star shape. Colours and shapes are the primary characteristics of an object. The appearance of an object is not limited to colour and shape. Texture and smell are also attributes of an object. Usually, our first contact with an object is visual, with its colour and shapes, before other senses of contact such as touch and smell take place. Colour and shape can convey useful information related to human safety and knowledge. Human can justify the freshness of food via colour and shape. In addition, the knowledge of colours and shape may have effect on other learning areas such as the development of aesthetic, art and design, and personal dressing and appearance.

Clements and Sarama (2014) had conducted a study of young children's shape recognition and found that hexagon, circle, triangle, and square were common and easy to identify when compared with other shapes like rectangle and oval. However, further investigation of the scope of shape to be learned by 4 year-old children is required as the preference for particular shapes may differ by culture (Clements & Sarama, 2014).

As mentioned earlier, children can learn faster with familiar objects or the things with which they have visual contact very frequently. The learning of colours can be started with primary hues[1] (red, yellow, and blue), followed by secondary hues (orange, violet, green), and extended to the immediate environment (i.e. black (complexion) and white (clouds)) (Althouse, Johnson, & Mitchell, 2003). Still, further study on the appropriateness of colours for 4 year old child is crucial as the preference of colours is affected by social and cultural backgrounds (Althouse et al., 2003).

Children's lives have a close relation with numbers. They come across numbers every day. Beginning with their hands and fingers, the toys they play with, and lastly, the food (i.e. biscuits, candies, and etc.) they consume, everything is about numbers. In fact, children have a lot of opportunities to develop number sense and counting skills. Early numeracy skill involves counting skills with numbers and objects (Coplan et al., 1999). Through the process of counting, children develop the concept of number and understand the meaning of Arabic numerals (1-10). Early numeracy development helps to build a strong foundation for advanced mathematics learning. Therefore, the number concepts and counting skills are essential for early childhood development and should be started as early as possible. Lena Damovska and Simona Palcevska (2009) recommended that early childhood development in the domain of mathematics and numbers should cover the recognition of numbers from 1-10 as well as counting skills. Yet, it is necessary to further examine the scope of learning for numbers to ensure the suitability of learning and development level for 4-year-old child.

[1] Hue is the name of colour

2.6.2 Cognitive Development

The general goal of ECCE is to promote the development of children from cognitive, physical, and social perspectives (Mishra, 2009). Cognitive development involves the areas of information processing, intelligence, reasoning, language development, and memory (Bjorklund, 2013). Besides, literacy and numeracy skills also play an essential role in cognitive development (Rose, 2014). In addition, decision-making, visual processing, attention, sensory integration and thinking skill are also important areas of cognitive development (Martinovic, Burgess, Pomerleau, & Marin, 2015). As there is a wide range of cognitive skills to be developed, it is crucial to examine which skills are appropriate and are immediately needed to cultivate preschool children development.

To solve a problem, the domain knowledge of the particular problem is required. Then, the problem solving process will proceed to generate a proper plan with workable strategies and possible solutions. After evaluating all the available choices (solutions), a person will enter the decision-making process to select the best or most appropriate solution to handle the given problem. The problem solving process actually involves all kinds of thinking abilities such as reasoning skills, information gathering and processing skills, creativity, and decision-making skills (Kim et al., 2009; Shih, Shih, Shih, Su, & Chuang, 2010). Chen, Sanchez, and Campbell (1997) reported that infants at 13 month old can solve simple problems like getting a toy from behind a barrier (i.e. box). Games can stimulate the ability of decision-making as well as problem solving through the presentation and manipulation of a problem (Shih et al., 2010). Thus, it is possible to develop problem solving and decision-making skill starting at preschool age through GBL.

Working memory[2] plays a key role in early childhood learning especially for symbol representation (i.e. numeral and word) (Waxman & Leddon, 2002) and reading (pronunciation) (Dufva, Niemi, & Voeten, 2001). Goswami and Bryant (2007) emphasized the importance of memorising skill in language and mathematics learning in their review of children's cognitive development and learning. On the other hand, attention[3] works closely with memorisation skills as it helps to retain and recall information. Although the relevant research on preschool age children is scant, their working memory and attention control can be improved through computer learning (Fernández-Molina et al., 2015).

Sensory development via the five senses (touch, smell, taste, sight, hearing) allow different types of information to be received, processed, stored, and learned. The well-known virtual learning environment (VLE) project – Cave Automatic Virtual Environment (CAVE™) has successfully drawn the attention of researchers to the use of virtual reality (VR) technology in teaching and learning (Cruz-Neira, Sandin, DeFanti, Kenyon, & Hart, 1992). CAVE™ operates in a room with walls, ceiling and floor. The learner uses a head-mounted display (HMD) or other equivalent device to view the projected image controlled by a computer. Roussos et al. (1997) designed a research called NICE (Narrative-based, Immersive, Constructionist/Collaborative Environment) based on the CAVE™ system. NICE created a virtual garden to allow a group of children aged 6 to 10 years to learn about complex ecological interrelationships. The children who participated in the project used the HMD for visual information and a light-weight hand-held device for interaction (water plants and pick

[2] Working memory is defined as a memory system for short-term recall (U. C. Goswami & Bryant, 2007).

[3] Attention can be understand as an ability to maintain his/her focus and remain alert to stimuli over prolonged periods of time (Hansen, Johnsen, & Thayer, 2003).

vegetables). They collaborated with each other at different locations via a network connection. The findings showed that NICE offered promising engagement in learning activities and were able to simplify the abstract concepts and complex mechanisms of ecological systems to young children. Limniou, Roberts, and Papadopoulos (2008) also conducted research on CAVE™ to facilitate chemistry learning. The participating students were compared in two learning environments, namely two dimensional (2D) and three dimensional (3D). Their comprehension of molecule structure was improved significantly in the latter condition because the molecules could be viewed at different angles via a joystick. Moreover, the changes that happened to the structure of molecules during the chemical reaction could also be understood more clearly through viewing from various angles. However, it is expensive to implement and maintain a 3D system because it requires special devices such as multiple projectors, 3D surround system, hand gloves, and HMD (Huang, Rauch, & Liaw, 2010; Miles et al., 2012). Besides, the learners may face with health issues such as motion sickness and hygiene issues if using the VR system for a prolonged period of time (Costello, 1997; Pölönen, Järvenpää, & Bilcu, 2013).

The current GBL focuses on visual processing skill for cognitive skill development (Bailey & West, 2013a; Cohen & Hegarty, 2014). Most of the visual or spatial skill development studies are related to mathematics, science, and geology (Cohen & Hegarty, 2014; Pittalis & Christou, 2010; Yang & Chen, 2010). The areas of development included spatial transformation (mental rotation[4]) (Lin & Chen, 2016; Meneghetti, Borella, & Pazzaglia, 2016; Merchant et al., 2013; Yeh et al., 2014), spatial structuring (Olkun, 2003; Wineman & Peponis, 2010), visual skills and perception

[4]Mental rotation requires identifying a 2D shape or 3D object when presented at a different orientation (Harris, Newcombe, & Hirsh-Pasek, 2013).

(Appelbaum, Cain, Darling, & Mitroff, 2013; Bailey & West, 2013b; Rengier et al., 2013; Uttal et al., 2013).

However, the majority of the visual/spatial studies focused on older children (aged 11) and above (Höffler, 2010). The visual/spatial ability of young children remains a puzzle due to limited empirical evidence. Rigal (1996) investigated children's spatial organisation ability and reported that children can only apply right and left terms correctly in naming their body parts at aged 7. Children at aged 11 still have difficulty in imagining a 180 degree rotation perspective. Sandamas and Foreman (2007) also reported that children's spatial learning improved with age and experience, with training and the developmental level having effects on their progress in spatial learning. The research conducted by Van Nes and Van Eerde (2010) showed that there exists an interrelationship between number sense and spatial sense, but children's spatial ability in visualizing 3D object construction (blocks) was still undeveloped because of the level of understanding and experience in working with object construction like block building. Harris et al. (2013) also stated that children's spatial transformation (mental folding) ability appears at around 5.5 years of age. In addition, Meneghetti et al. (2016) reported that most of the participants under the age of 7 had not yet developed the 3D mental rotation skill.

Due to the limitation of technology and the concern for safety, sensory development involving the senses of touching, smelling and tasting currently may not be applicable for implementation in preschool GBL. For visual and audio processing skill development, it might be more suitable for primary and secondary school students than for preschool children because of the former's maturity in thinking ability and also the experience with the mental rotation task. Based on the above findings, the cognitive development for preschool children can begin with problem solving, decision-making, and memorisation skills.

2.6.3 Psychomotor Development

Apart from cognitive development, physical development is also important to ensure holistic development of the child. Based on the literature on the impact of a physical curriculum to a child, a healthy and active child usually has better academic performance than an inactive child or one with a low engagement level of physical activity (Daniels, 2009; Shephard, 1997; Staiano & Calvert, 2011; Tomporowski, Davis, Miller, & Naglieri, 2008). Participation in physical activities such as sport and fitness games encourages the practice and training of various motor skills. A child is building his/her physical and mental health when performing an exercise or engaging in a physical activity. The child practices his/her attentional control and discipline which may help to develop better learning attitude.

Physical development emphasises developing fundamental motor skills and psychomotor skills. Fundamental motor skills includes those movements of hands and/or legs to perform an action such as body balance, ball catching/throwing skills, running, and jumping (Iivonen, Sääkslahti, &Nissinen, 2009). Psychomotor skills refer to the motor skills that are required for attention and coordination ability (Harrow, 1972). Besides, psychomotor skills are also required for the mastery of cognitive concepts such as catching a ball based on a given condition or throwing a ball at a target (Thomas, 2004).

Physical development plays a key role in early childhood development for building self-esteem, motor skills, physical health and cognitive learning (Liddle & Yorke, 2004). Milestones of development and movement for a child at aged 4 should include jumping, hopping, balancing and ball catching (Green-Hernandez, Singleton, & Aronzon, 2001). Through physical activities, children practice the correct technique to throw and catch a ball and at the same time train for hand-eye coordination as well as control of body balancing.

Table 2.4: List of fundamental motor skills and psychomotor skills for preschool children's physical development

	Fundamental motor skills	**Psychomotor skills**
Hands	• Pushing • Pulling	• Ball catching/throwing • Rolling
Legs	• Sliding • Galloping • Jumping • Skipping • Running	• Kicking a ball at a target
Body balance	• Static balance ➢ Stand on left leg ➢ Stand on right leg	• Dynamic balance ➢ Jumping side-ways

Table 2.4 summarises the fundamental motor skills and psychomotor skills taken from studies of 4 year old children's physical development (K. Iivonen et al., 2013; Susanna Iivonen et al., 2016; Iivonen, Sääkslahti, & Nissinen, 2009; Rintala, Pienimäki, Ahonen, Cantell, & Kooistra, 1998). However, appropriateness of learning the aforementioned motor skills depends on the development trajectory. Therefore, further examination is required to ensure that learning motor skills is suitable and fit preschool child development.

2.7 GBL Intervention for Pre-schoolers

The quality of preschool education can affect the process of acquiring foundational knowledge and skills by a child. Besides, it also has an impact on his/her transition to primary school and preparation for various academic challenges. A few studies supporting the fostering of pre-schooler cognitive and psychomotor development through GBL were reviewed.

2.7.1 Review for Preschool's Cognitive Development Studies

Starting from early childhood, a child explores the world through the five senses, learning, and various kinds of play. The child develops his ability to differentiate objects via sensory organs, communicate with people, and play and work together with peers during the stage of early childhood. In addition, early cognitive development also has a close relationship with early memory development. Causal reasoning and explanation (i.e. problem solving), language, as well as mathematics development, also correlates with early cognitive development (Goswami, 2011).

Praet and Desoete (2014) conducted a game intervention program to enhance pre-schoolers' arithmetic skills. The program was conducted for 5 weeks, totalling 9 sessions (25 minutes per session). 132 pre-schoolers participated in the intervention program and were randomly assigned to one of three groups: control group (n=49), counting games group (n=44), and comparison games group (n=39). Number knowledge and mental arithmetic performances in the counting games group were improved, as did number knowledge proficiency in the comparison games group. The strategies used for this intervention group to enhance the pre-schoolers learning included choosing simple but enjoyable games, the adoption of useful feedback, and properly designed learning content. The games selected for learning were simple, fun and required little instruction. In addition, visual (happy or sad smiley) and audio (sob for mistake and applause for correct answer) feedback was used to provide the pre-schoolers with funny, immediate, and straightforward responses to their actions. This study set a good example for GBL in fostering preschool learning, where properly designed content and appropriate feedback could deliver arithmetic skills in an effective manner.

Reading is an essential skill for building a foundation for language development and knowledge acquisition. Homer et al. (2014) conducted a study by embedding games that utilised gesture-based interaction into the story reading process to engage preschool children in literacy activities. 39 pre-schoolers participated in the study and were randomly assigned to one of three groups: *Book Reading* group (n=14), *Kinect without activities* group (n=13), and *Kinect with activities* group (n=12). All the children went through the story one time. The *Kinect with activities* group and *Book Reading* group had significant gains in high frequency words, active decoding, and total reading score but only the *Kinect with activities* group had a significant gain in sight words. The use of in-game activities engaged the children in literacy activities and supported the acquisition of language and literacy skills. In addition, the findings also showed that gesture-based activities promote learning from the digital story and thus shed light on the potential of gesture-based technology in facilitating children's learning.

Fessakis, Gouli, and Mavroudi (2013) investigated the problem solving skills of 10 kindergarteners (6 boys and 4 girls) in a computer programming environment. The kindergarteners played a game using a mat, a Ladybug toy and cards to get familiarised with the symbols and logic of the software environment. Then they were involved in six exercises and one maze problem solving task. 5 of them completed the problem solving tasks without any assistance, 3 kindergarteners required at least one hint or suggestion to accomplish the tasks and the remaining 2 kindergarteners were not able to solve any task. The use of the game to teach the kindergarteners about the concept of programming and problem solving set a good example for future research. The familiarity with the software environment reduces resistance to use the software for learning and working, thus, fostering problem solving and logical thinking skills. However, it is hard to infer about the effectiveness of the intervention program to other kindergarteners due to the small sample size.

Duh, Koceska, and Koceski (2016) designed a tablet application, namely Azbuka, to develop preschool children's writing skills for eight selected Cyrillic letters ('A', 'и', 'E', 'M', 'O', 'з', 'Ц', and 'B'). 18 children aged 4 to 6 years were recruited for this study and divided into two groups: experimental group (n=10) and control group (n=8). All the children were novice users of the touch screen tablet device. The experimental group learned two letters per day; each letter was repeated 10 times. They were provided with two types of feedback, short-term and long-term feedback. The former gave immediate response to alert the children of wrong movement or completion of levels whereas the latter was for achievement and performance of each level in the game. The control group used the normal classroom method (colouring and writing) to learn the respective letters. The experimental group used less time to draw a letter in the tablet device than the control group, who wrote the letter using a pencil. Although the children (experimental group) were highly motivated to learn writing Cyrillic letters through the use of a tablet device, the study did not test their handwriting skill as done with the control group. Therefore, the transfer of handwriting skill using tablet device remains puzzled.

Table 2.5 summarises the findings and areas of cognitive development for existing pre-school GBL intervention program. The success factors for the respective studies are also analysed. The findings were not consistent due to the evaluation method and research design. Moreover, the amount of literature for pre-schoolers is scant, and there is a need to provide more scientific evidence and insight in promoting the cognitive development of pre-schoolers and discover potential areas of development.

Table 2.5: Summary of preschool GBL intervention programs for cognitive development

Collected Study	Cognitive Development	Findings	Remark
Praet and Desoete (2014)	Arithmetic skill	• Counting games improved number knowledge and mental arithmetic performances • Comparison games enhanced number knowledge proficiency	The success in enhancing children's arithmetic skill acquisition may be due to i. The game is simple, fun, and requires little instruction ii. the use of playful, immediate, and continuous feedback to assist the learning iii. the content's focus on procedural and conceptual counting knowledge but at the same time engages the children with games
Homer et al. (2014)	Language and literacy skill (reading)	• The *Kinect with activities* group and *Book Reading* group had significant gains in high frequency words, active decoding, and total reading score. • Only the *Kinect with activities* group had significant gain in sight words.	The use of in-game activities engaged the children with literacy activities and supported the acquisition of language and literacy skills. Also, gesture-based control eased the interaction between children and the game system and was therefore suitable for informal learning.
Fessakis et al. (2013)	Problem solving skill	• 50% of the participants completed the problem solving tasks without any assistance, 30% required at least one hint or suggestion to accomplish the tasks and the remaining 20% were not able to solve any task.	The use of game to teach the concept of programming and problem solving could assist the kindergarteners in exploring the software environment and understanding the logic of programming, and as a pleasant and enjoyable experience. However, the sample size was too small to draw a conclusion for the effectiveness of the intervention program.

Table 2.5, continued

Collected Study	Cognitive Development	Findings	Remark
Duh et al. (2016)	Writing skill	• The results revealed that the time required to draw a letter using the application is less than the time taken for writing the letter using pencil. • The children were highly motivated to learn writing Cyrillic letters	The factors that engage the children with learning are i. The game is simple, fun, and requires little instruction ii. Two types of feedback are used. Short-term feedback gives immediate response on mistake or completion of level whereas long-term feedback for achievement and performance of each level in the game. However, there was bias in evaluating the children's writing skill because the handwriting skill (use of pencil) of the children who trained using the tablet was not tested unlike the control group.

2.7.2 Review of Pre-schoolers' Psychomotor Skill Development Studies

Motor skill development started at infant stage. Vygotsky (1967) stated that an infant knows how to entertain himself through the act of sucking a pacifier or finger. Through the practice of the respective organ or body part, they start to learn how to control their muscles and develop basic motor skills. The stimulus for children to develop various motor skills can be the surrounding environment, toys, family members, and food. Motor ability is not only important for movement from location to another location but also for taking care of routine needs such as eating, learning, working, and playing. The following studies analyse the strategies used to promote the motor skill development of preschool children. In addition, the important areas when designing a GBL system to foster the psychomotor development of pre-schoolers are also discussed.

Vernadakis et al. (2015b) had conducted a study to examine the difference between exergame intervention and the traditional object control skills training program. 66 children aged 6-7 years participated in the study for 8 weeks, two times per week, and 30 minutes per session. Based on the findings, the object control skill of children who took part in the exergame intervention improved significantly, and they enjoyed the exergame intervention more than traditional training program. However, the results could not be generalised due to the small sample size. The presence of a motor skill instructor to provide guidance and feedback to the children was one of the key factors in fostering the children's motor skill acquisition. Besides, the training content was designed to facilitate the structured motor skill learning and training as well as the player's engagement. The balance between learning and play successfully engaged the children with motor skill development. Moreover, the use of somatosensory[5] game

[5]Somatosensory game console utilizes user's gestures and body movements to interact with the video games and did not rely on the use of remote controller or joystick (Chiang, Tsai, & Chen, 2012).

console (without controller) accelerated the motor skill development by abandoning the use of a remote controller.

A study to assess the efficacy of an intervention on gross motor skill performance, physical activity, and weight status of pre-schoolers, was conducted by (Bellows, Davies, Anderson, & Kennedy, 2013). 201 children aged 3-5 years joined the intervention program and were divided into two groups: treatment group (98) and control group (103). The intervention program was conducted for 18 weeks, 4 days per week, with 15-20 minutes per day. The treatment group showed significant improvement in gross motor skills compared with the control group. However, the intervention program had no effect, neither on the children's physical activity levels nor on their weight status. The fact reveals that the high fidelity of the program and teacher control were the strategies that ensured the success of the program's implementation.

Other studies in the literature state the reverse. Barnett, Hinkley, Okely, Hesketh, and Salmon (2012) investigated the impact of playing active video games (AVG) on children's actual and perceived object control skills. The children's object control skill improved over time and they were engaged with their respective sports. However, playing AVG did not foster the development of the children's movement skills and most of them did not perceive direct equivalence between AVG and physical activities. Johnson, Ridgers, Hulteen, Mellecker, and Barnett (2015) also questioned the utility of the video game console for developing perceived and actual object control skill for children. The failure of the AVG in facilitating children's motor skill acquisition may be due to the absence of a teacher/instructor in giving feedback and control. Apart from this, the design of the content tended to focus on player engagement and the use of the game controller eliminated the opportunity for developing and practicing the required movement skill.

The limited number of publications focusing on pre-schooler physical development intervention showed that it is at the nascent stage of development (Ward, Vaughn, McWilliams, & Hales, 2010). The studies that cover both the cognitive and psychomotor development of preschool-aged children are even scarcer. Hsiao and Chen (2016) proposed and implemented a gesture interactive GBL approach to improve the learning performance and motor skills of pre-schoolers. The children who participated in the game intervention program demonstrated better learning performance and motor skills when compared to those who learned through the traditional approach. The intervention program was limited by a short time frame for training and the small number of participants. The keys to success in facilitating children's learning and motor skill acquisition included the design of content, the use of a somatosensory device, and also the use of proper instruction and immediate feedback to facilitate the children's learning.

Table 2.6 summarises the findings and areas of development for existing pre-school GBL intervention program. The amount of literature on the physical development of pre-schoolers is scant. Children with poor fundamental motor skills during preschool and elementary school years may have problems in the development of complex motor skills as well as control of specialised movements during adolescence and adulthood (Akbari et al., 2009). Moreover, it may also lead to low physical activity levels and obesity issues. Therefore there is a need to have more studies on this area to provide more scientific evidence and insight on how to foster various motor skills and at the same time promote the cognitive development of pre-schoolers.

Table 2.6: Summary of preschool GBL intervention programs for motor skill development

Collected Study	Psychomotor Skill Development	Findings	Remark
Vernadakis et al. (2015b)	Object Control Skills	• children's object control skill improved significantly after participating in the exergame intervention • children enjoy the exergame intervention more than the traditional training program	The success in fostering children's motor skill acquisition may be due to i. the presence of a motor skill instructor to provide guidance and feedback to the children ii. the content focuses on the player's engagement and also structured motor skill learning and training iii. the use of somatosensory game console (without controller) encouraged motor skill development
Bellows et al. (2013)	Gross motor performance	• The treatment group showed significant improvement in gross motor performance	The success in fostering the children's motor skill acquisition may be due to i. the fidelity of the program was high ii. teachers' monitoring and control on daily basis
Barnett et al. (2012)	Object Control Skills	• children's object control skill improved over time • successfully engages the children with sports	The failure in facilitating children's motor skill acquisition may be due to i. the absence of a teacher/instructor ii. the content focuses on player's engagement more than structured motor skill learning and training iii. the use of game console with controller did not encourage the motor skill development iv. the training time was insufficient

Table 2.6, continued

Collected Study	Psychomotor Skill Development	Findings	Remark
Hsiao and Chen (2016)	Motor skills (agility and coordination) and language development (colour recognition)	• The children who participated in the game intervention program demonstrated better learning performance and motor skills when compared with those who learned through the traditional approach.	The success in facilitating children's learning and motor skill acquisition may be due to i. the content focuses on content and motor skill learning and training ii. the use of somatosensory game console (without controller) encouraged motor skill development iii. the use of instruction and feedback facilitate children's learning

2.8 GBL Technology

Children of the present day, unsurprisingly, are familiar with innovative technologies such as mobile technology, VLE, and gesture computing. They can adapt to the VLE and do not resist exploring, learning, and using digital devices such as smart phones, televisions, and game consoles. With the advancement of technology, VLE can now be deployed on various platforms such as the desktop-based computer, mobile phone, touch screen tablet device, and also the somatosensory game console. Many GBL research studies utilise the VLE to stimulate the interest of learners and engage them with learning. However, each platform has its strengths and weaknesses for learners as well as limitations from hardware used to deliver the content of GBL. The following section analyses some of the popular platforms used for implementing GBL, such as desktop, cellular, tablet, and somatosensory device.

2.8.1 Desktop Platform

Many children were raised in the digital era and are familiar with various kinds of digital devices like the smart phone, tablet, and computer. Prensky (2001) labelled this generation of children "digital native". The popularity of computer technology in routine life has caused a high penetration rate of computers in the household market in the last two decades. Since year 1980, the potential, role, and effectiveness of the computer as an educational tool of learning in preschools have been debated (Degelman, Free, Scarlato, Blackburn, & Golden, 1986; Hess & McGarvey, 1987; Simon, 1985; Watson, Nida, & Shade, 1986).

With the use of proper computer games and sufficient training, children can improve their mathematic performance (Kraus, 1981; McCollister, Burts, Wright, & Hildreth, 1986). Moreover, the potential of computer learning in problem solving (Fessakis et al., 2013), decision-making (Clements, 2002; Riding & Powell, 1987), and literacy skill (Van Daal & Reitsma, 2000) were also discovered. Li and Atkins (2004) revealed that children who had early computer experienced had a higher score for school readiness and cognitive development when compared to those who had no access to a computer. However, this early computer exposure did not promote visual motor (hand-eye coordination) and gross motor skills of preschool children.

The early stage of the desktop computer comprised a central processing unit (CPU), keyboard, mouse, and two speakers. The user relied on the keyboard and mouse to interact with the computer and to perform computer tasks. Sitting in front of a computer for a prolonged period of time may lead to physical health issues related to vision *(*Mvungi, Mcharo, Mmbuji, Mgonja, & Kitua, 2008), posture (Dockrell, Earle, & Galvin, 2010), muscle and joint injuries (Blatter & Bongers, 2002),and a sedentary lifestyle (Chiang et al., 2012). These drawbacks are severe for younger children because they are at the developmental stage. To conclude, the desktop may be not a suitable platform for preschool GBL because it may increase the risk of having improper posture and engaging with sedentary activities, which prevent them from building a healthy and active lifestyle.

2.8.2 Cellular Platform

The maturity of the mobile network technology has brought changes to human lifestyles. The thickness of a smart phone as well as its weight has been reduced significantly. Long battery life and high processing power allow the smart phone to be used for various purposes including communication, entertainment, learning, and working.

Many studies of mobile learning platform reported positive gains in achieving desired learning goals in cognitive development such as knowledge acquisition (Hwang et al., 2011; Ward et al., 2013), literacy (Beschorner & Hutchison, 2013; Couse & Chen, 2010; Neumann & Neumann, 2014), and problem solving (Chang et al., 2011; Sánchez & Olivares, 2011). However, its potential for psychomotor development is yet to be discovered. Currently, it is limited to fine motor skills such as drawing (Vinter & Perruchet, 2002) and finger gesture (tap and drag) (Noorhidawati et al., 2015). Although the mobile learning platform consists of a number of benefits, the overuse of the smart phone can bring negative effects to a child, for example, problematic behaviour[6] and emotional intelligence[7] (Cho & Lee, 2017).

2.8.3 Tablet Platform

The widespread use of mobile phones and computers raise the need for the tablet device, which offers mobility to the user and at the same time provides functionality similar to that of a computer. The use of the tablet device as a learning tool in school is becoming common and important. Tablet device requires a stylus[8] to interact with the touch screen for making a choice, launching an application, drawing, writing, and colouring.

Couse and Chen (2010) conducted a study on the viability of the tablet for preschool children and found that they quickly developed ease with the stylus for drawing. Besides, the interest in the device allowed the children to persist without frustration when facing technical issues during their learning. However, the high engagement with the tablet device raises a health concern, especially for young children due to the long hours of usage. A study comparing the posture and muscle activity of preschool children during tablet computer, desktop computer, and paper use was conducted (Straker et al., 2008). The findings revealed that the effect of tablet computer was similar to paper use. The physical impact such as musculoskeletal symptoms and posture problem, however, remains a puzzle.

[6] Problematic behaviours refer to behaviours that are uncustomary and deviant in terms of general social norms and ethics (Cho & Lee, 2017).

[7]Emotional intelligence refers to the ability to perceive emotions, to access and generate emotions so as to assist thought, to understand emotions and emotional knowledge, and to reflectively regulate emotions so as to promote emotional and intellectual growth (J. D. Mayer & Salovey, 1997)

[8] The stylus is a pen-shaped tool that is used to interact (i.e. writing, drawing, or tapping) with the touchscreen device.

2.8.4 Somatosensory Platform

Rapid development in the game industry brings evolution to the game system. The competition between video game companies, and players' needs and demands (i.e. gender, age, interest, need and etc.) has led to massive changes in the game device, quality of graphic and sound, game genre, storyline, and the player’s gaming experience. VR devices (i.e. HMD, Manus VR grove, HTC Vive, Oculus Rift, etc.) were introduced to replace the joystick and game controller to allow players to have seamless interaction with the game system and 3D VR gaming experience. The emergence of the somatosensory device/game console starts a new chapter in gaming technology.

Nintendo Wii (Wii U), Microsoft Kinect (Xbox One), and Sony PlayStation (PlayStation 4) are the current gaming console systems that utilise somatosensory devices. Wii U does not offer voice command and thus it still requires a handheld controller for system interaction purpose. Although PlayStation 4 provides voice control interaction, players still have to use a handheld device for motion control. With the use of cameras and microphones, Xbox One allows players to communicate and interact directly with the game system through voice and gesture commands. The players are no longer sitting on the floor and using a game controller to play a game but move the body, hands, and legs in order to play a game. In other words, the somatosensory game console promotes more bodily movement than the conventional game system. Controller-free, voice control, and gesture-enabled environment seem to encourage an active lifestyle.

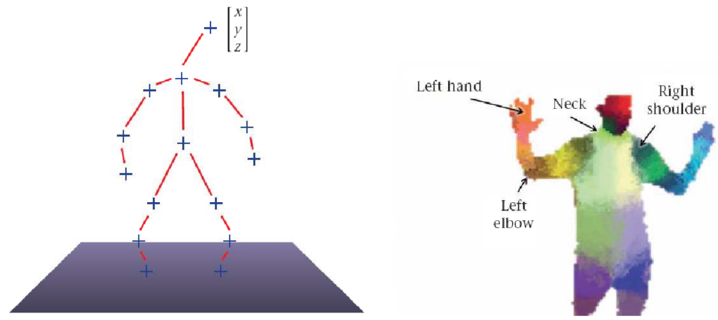
As voice and gesture command play an essential role in system communication for somatosensory game console, the underlying algorithms used for voice and gesture recognition were studied. Deep Neural Network (DNN), dynamic time warping (DTW), Hidden Markov models (HMM), and neural networks are common algorithms for speech and gesture recognition.

DNN is an artificial neural network with many multiple hidden layers between its inputs and outputs (Hinton et al., 2012). It is used as an acoustic model in speech recognition to translate the human speech into text. Based on reviews, these features have been successfully used for a large vocabulary and improved the speech recognition process in many areas such as noisy speech and vocal tract differences between speakers (Deng, Hinton, & Kingsbury, 2013a). Other speech recognition algorithms such as DTW, HMV, and neural networks are still in used by some business application. However, the aforementioned algorithms have limitations in its accuracy for recognising human speech.

DTW usually works well with linear representations such as video, audio and graphics. However, it has problems working with large databases and real time human speech processing (Zhang, Sun, Luo, & Li, 2013). HMV utilises the pattern matching approach to find the best matched or the closest pattern of speech for the detected speech. This model may cause a high word error rate because it discards information about time dependencies and is prone to overgeneralisation (Anusuya & Katti, 2010). Neural network is an artificial intelligence approach that learns human speech using network training. Yet, it still has difficulty handling continuous speech or long word recognition (Bourlard & Morgan, 2012). DNN overcomes the above limitations by providing deep learning of various human speaking styles such as accent, pitch, pronunciation, speed, and volume.

Human communication is not restricted to verbal conversation. Body language such as sign language can also be an alternative channel to convey message or information. Sign language is a structured set of various types of gesture used by deaf people or those with hearing and speech impairments for communication purposes (Starner, Weaver, & Pentland, 1998). Early research in gesture recognition focused on the use of hand gestures as a natural interaction between the human and various computer-controlled displays (Pavlovic, Sharma, & Huang, 1997). Many fields such as art, human-computer interaction, sign language communication, robotic, gaming, and health benefit from this technology (Pavlovic et al., 1997). The advancement in gesture recognition technology allows it to expand its contribution to health care, physical therapy, retail, education, and training (Tashev, 2013).

For gesture recognition, DNN, DTW, HMM, and neural networks differ in performance in recognizing different body parts. For example, HMM has better performance in recognising the continuous hand's motion tracking (Yang, Jang, Beh, Han, & Ko, 2012). Recently, skeletal tracking algorithm has been used to analyse captured information of a player's movement. Skeletal tracking is a 3D gesture recognition algorithm. In the skeletal tracking system, the main body parts such as the head, neck, shoulders, hands, and legs are represented by a number of joints, as depicted in Figure 2.7 (a). Each joint has its 3D coordinates and respective parameters for real time movement processing and computation. The next step of the algorithm is to perform per pixel, body part recognition before mapping it into the skeleton of a virtual character (see Figure 2.7 (b)). Once the mapping has been completed, the virtual character will show the same move as the player does. It was adopted because it has better performance for recognising human gestures at real time as compared to other algorithms (Zhang, 2012).



(a) Skeletal representation (b) Body part recognition

Figure 2.7: Skeletal tracking (Zhang, 2012)

2.8.5 Comparison of Platform

Table 2.7 summarises the benefits and drawbacks of using the abovementioned platform for the purpose of learning. Overall, each platform has its own advantages in promoting children learning and development. However, each platform also contributes to different types of health problems due to misuse, hardware limitation, and system design.

Based on the review conducted by McCarrick and Li (2007), the computer did not facilitate children's language development but cognitive development. Besides, the use of the computer mouse may trouble young children with learning activities that require accuracy in clicking and aiming at target objects. Donker and Reitsma (2007) reported that children have problems with aiming and moving small target objects. The performance of using a mouse (i.e. aiming and moving object) could be improved when bigger target objects were used. Another drawback of using computers is that children may suffer from computer-related physical discomforts (Jacobs & Baker, 2002). Moreover, sitting in front of a desktop computer for hours on a daily basis can lead to sedentary behaviour and limit other areas of development such as gross motor and fundamental movement skills.

Table 2.7: Comparison of multiple platforms for the implementation of GBL system

	Platform			
	Desktop	**Cellular**	**Tablet**	**Somatosensory**
With controller/ handheld device	✓	✓	✓	✗
Health issues				
• Encourage sedentary lifestyle	✓	✓	✓	✗
• Vision problem	✓	✓	✓	✓
• Posture problem	✓	✓	✓	✗
• Muscle and joint injuries	✓	✓	✓	✓
Encourage active lifestyle	✗	✗	✗	✓
Mobility	✗	✓	✓	✗
Facilitate language development	✗	✓	✓	✓
Foster cognitive development	✓	✓	✓	✓
Motor skill development				
• Fine motor skill	✓	✓	✓	✗
• Fundamental motor skill	✗	✗	✗	✓
• Psychomotor skill	✗	✗	✗	✓
Easy to learn and use	✗	✓	✓	✓

Generally, the cellular and tablet platforms are similar in many ways. These two platforms provide multi-touch interaction simplifying the input commands (i.e. typing and clicking) and reducing the difficulty and frustration in learning caused by the inaccurate aiming action. Besides, the review of these platforms also indicated that the use of multi-touch interaction supported preschool children in learning and facilitated collaboration among peers, as well as engagement with the learning environment (Nacher et al., 2016). The only limitation for these platforms is that it is not suitable for physical exercise or motor skill development.

The development and mastery of fundamental motor skills is crucial for a child to learn new skills, play games, perform daily activities, and support his/her physical development. The current gaming console system such as Kinect utilising gesture recognition technology to detect the players' gesture and recognise their movement in real time basis (Tashev, 2013; Yi, 2012). The players are no longer depending on the game controller or joystick for system interaction purposes. Miles et al. (2012) recommended that gesture recognition technology be used to improve motor control skills in ball sports. Sun (2015) also suggested that the integration of gesture recognition technology with sport games could be an innovative approach for the motor skill acquisition and development of children and adolescent. Other studies claimed that this approach was effective in preventing sedentary lifestyle through engaging the players with various physical activities (Smallwood, Morris, Fallows, & Buckley, 2012; Sun, 2013) and psychomotor exercises (Graf, Pratt, Hester, & Short, 2009; Papastergiou, 2009b; Vernadakis et al., 2015a). Nevertheless, more empirical results are needed to support the effectiveness of gesture recognition technology in facilitating motor skills development (Papastergiou, 2009b). Based on the comparison made of the four platforms in Table 2.7, the somatosensory device is suitable for preschool GBL with minimum risk to health, ease of learning and use, and its potential in facilitating children's language and communication, cognitive, and psychomotor developments.

2.9 Age Appropriateness for Cognitive and Psychomotor Development

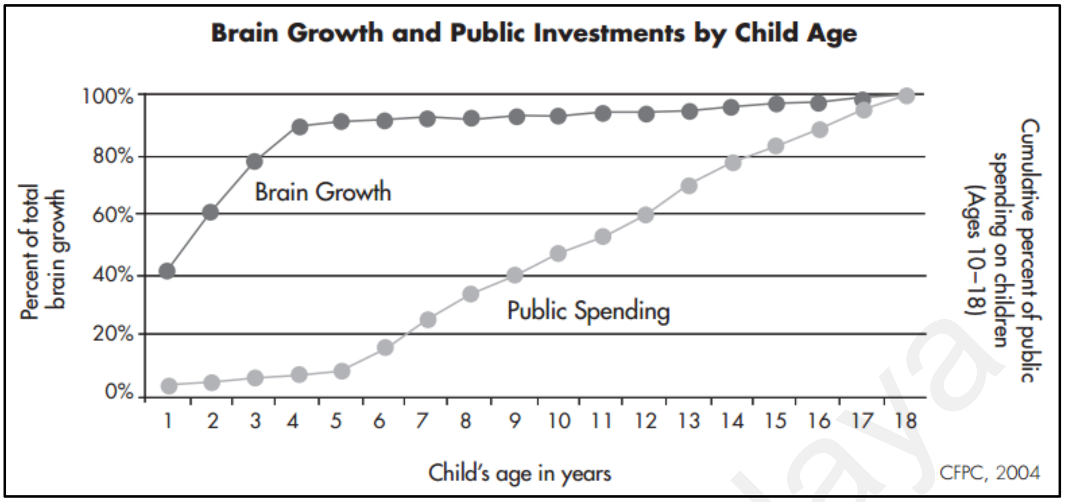


Figure 2.8: Brain growth and public investments by child age (Vargas-Barón, 2005)

Figure 2.8 shows the chart of brain growth and public investments by child age. Vargas-Barón (2005) conducted a study investigating the United States' public investment for children from age 1 to 18 and making a comparison for children's brain growth. As can be seen from the chart, a child's brain starts to grow rapidly at aged 1 and reaches an optimal level of growth at aged 4 but does not reach saturation till aged 13. This fact indicates that a child has excellent learning ability starting from aged 4. To fully develop the potential of young children, it is important to understand the time period of rapid growth in brain development before the window of opportunity is closed. Formally, Malaysia preschool education is for children aged 4-6 years old. Based on studies of children's brain growth, the proposed study is focused on preschool children at aged 4.

2.10 Summary

GBL has long been introduced and accepted as a promising learning vehicle. However, this innovative teaching/learning approach is still debated for its appropriateness and effectiveness in promoting child learning and skill development. There are several challenges that cause GBL not to be widely adopted as a teaching/learning approach in preschool education. First, the existing GBL framework is not tailored for preschool learning due to the focus on a facilitating rather than a teaching role. For older children or adolescents, a teacher is more suitable to play the role of facilitator than instructor. In contrast, pre-schoolers rely on the teacher's guidance and instruction for learning and practice. Therefore, the teacher has ineluctable role in GBL framework for preschool learning.

Secondly, the teacher as the implementer is the key to success or failure for GBL adoption in classroom learning. Due to lack of technological knowledge, technological support, and training, teachers encountered problems in adopting GBL. In addition, less familiarity with games means the teacher has to pay more time on preparing the game lesson. The adoption of GBL in preschool is to assist the teacher in teaching and engage the children in learning. Their worries can be addressed through their participation in program design and taking a role as facilitator and evaluator in the GBL framework.

The transfer of knowledge for preschool children is the third concern. To promote knowledge transfer, a similar context with the applied context is suggested. Scaffolding and feedback can also assist the knowledge transfer as well if the timing is correct and information provided is simple and straightforward. The appropriateness of content in facilitating pre-schoolers learning and development gains most of the attention of educators. Generally, preschool GBL can focus on the language and communication, cognitive, and psychomotor development.

The number of studies on preschool GBL intervention is scarce. Although there are many GBL programs for pre-schoolers, the effectiveness or appropriateness of the programs has not been evaluated. Besides, the platform for implementing GBL system is also a concern. By considering the benefits and drawbacks of each platform as well as its capability in promoting children's cognitive and psychomotor development, the somatosensory platform is selected as the most appropriate platform for this study (preschool's GBL).

The fact of brain growth reveals that children at aged 4 have optimum learning ability. Therefore, the proposed GBL framework targets 4 year old children, to investigate the effectiveness of GBL on preschool learning in facilitating their development of language and communication, cognitive, and psychomotor skill.

The next chapter will explain the research methodology in details. A research flow is used to describe the methods used in the research for information gathering, conducting survey, system design and testing, and data gathering and analysis.

CHAPTER 3:Research Methodology

3.1 Introduction

This chapter explains the approaches used to achieve the research objectives that were defined in Chapter 1. The details of the data gathering techniques, instruments used, and data analysis techniques are discussed in detail. The chapter summary, which concludes the research methodology, is presented in the last section.

3.2 Research Approaches

The flow of the research methodology is depicted in Figure 3.1. The research begins by studying the existing game-based learning (GBL) frameworks. The analysis of the strengths and limitations of these frameworks offers a better understanding of both the development and issues of GBL systems for facilitating children's learning. Besides this, the literature review also sheds light on the research direction and formulations of the following objectives:-

1. To propose a GBL framework for selected preschools to
   - assist teachers in teaching and assessing preschool children.
   - improve preschool children's learning in terms of language and communication, cognitive, and psychomotor development.
2. To design a virtual learning environment (VLE) based on the proposed framework.
3. To evaluate the ability and capacity of the proposed framework to
   - assist teachers in teaching and assessing preschool children.
   - improve preschool children's learning in terms of language and communication, cognitive, and psychomotor development.

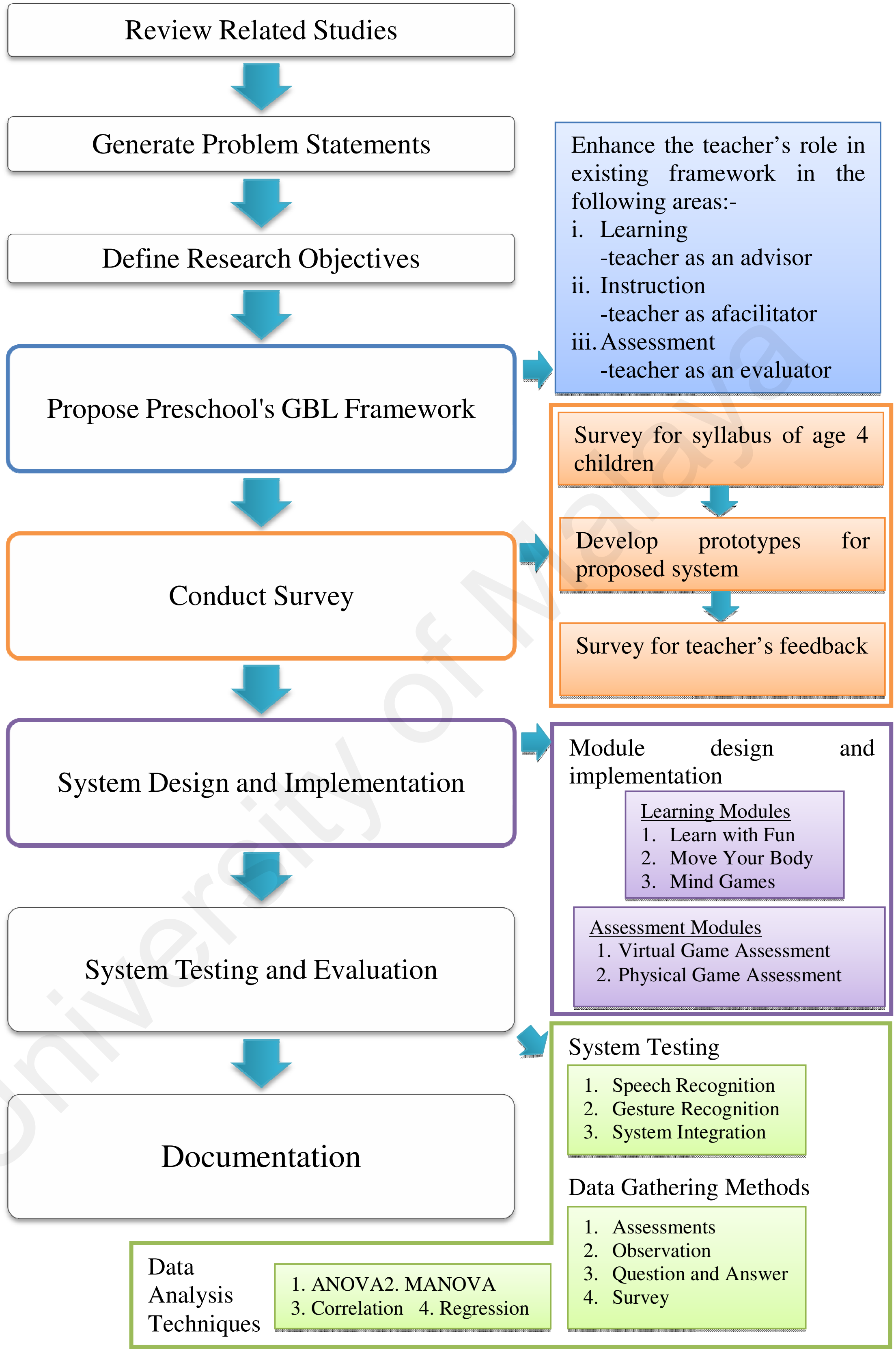


Figure 3.1: System flow of research methodology

3.2.1 Proposed Game-based Learning Framework

This section discusses the proposed framework and underlying activities that used to assist teachers in using GBL, as well as to engage teachers to promote knowledge transfer to the preschool children in learning, which is a core part of objective 1 (see section 1.4).

The Game-based learning framework proposed by Van Staalduinen and de Freitas (2011) provides a complete guideline for aligning learning, instruction, and assessment (refer Figure 2.5). However, the framework has limitations for promoting game-based learning (GBL) in preschool education due to the minimal involvement of teachers in these activities. In this research, the aforementioned framework is enhanced by an increase in the participation of teachers in the learning, instruction and assessment activities.

Figure 3.2 shows the enhanced Game-based learning framework. The enhanced framework consists of the existing activities, which are learning, instruction, and assessment. Each of these activities is enhanced to include the role of the teacher as well as the adjustment of focus to preschool education. The enhanced activities play an essential role in assisting the teachers in understanding learning style and progress of learners, and in the teaching and assessing learners via GBL approach. The game learning cycle is enhanced by two instructional models, which are learning model and transfer model to improve preschool learning. The proposed learning model is used in *Learn with Fun* and *Move Your Body* to help the preschool children acquiring new knowledge and skills whereas the transfer model is used in *Mind Games* to train the preschool children applying the knowledge and skills in a game simulated environment. Two types of assessment: *Physical Game Assessment* and *Virtual Game Assessment* are proposed to evaluate the knowledge transfer of preschool children in a virtual reality and reality contexts. A brief discussion of the enhanced activities is presented in the subsequent sections.

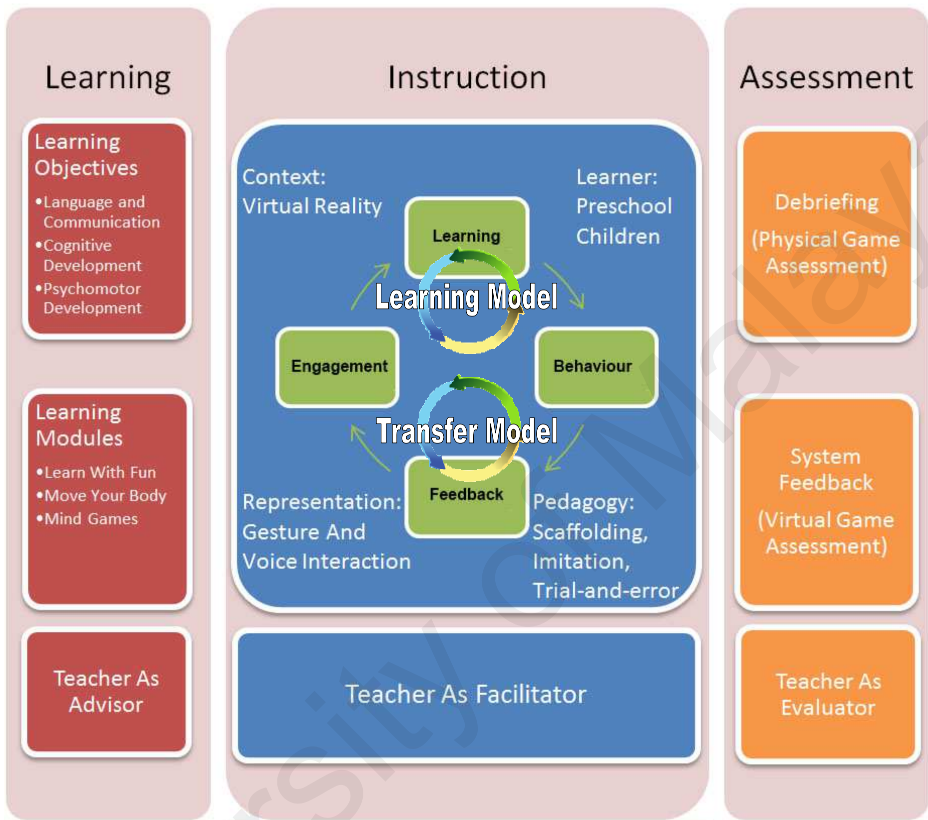


Figure 3.2: The enhanced Game-based Learning Framework

3.2.2 Learning

Learning can be understood as "an observable change in a person's reaction to an equally observable stimulus situation" (Schmeck, 2013). Learning can be interpreted as the outcome of interactions (reading or observation) with information (content) or people. Through learning, a learner can improve the level of knowledge and skill used for communicating with people, making decisions, and solving problems encountered in daily activities. In the perspective of an educational setting, learning has objectives and each academic subject consists of specific content or skills to be learned.

The learning activity in the framework consists of learning objectives, clear player goals and learning content. The learning objective is what the learner needs to learn while the player goal is what the learner can achieve in a game. The player goal can differ from the learning objective. For example, the strategy/solution used to win the game may not be related to learning. Lastly, the learning content is the pairing of educational content with game elements. The learning activity emphasises the importance of defining the learning objectives at the early stage of the game design. However, in the existing framework, the involvement of teacher is limit. Without the verification of teachers, the validity of learning content in delivering the learning objectives may not fulfil the requirement or benchmark from the educational perspective.

3.2.2.1 Learning Objective

This framework aims to improve preschool children's learning and the learning objectives are adjusted to cover three essential development areas for children which are language and communication, cognitive, and psychomotor. Generally, language and communication development is to help preschool children develop their pronunciation skills and the ability to learn new vocabulary in a language for their daily communication (Buckley, 2012). Cognitive development involves training preschool children in problem solving, decision-making, and memorising/recognising symbolic representation (Bjorklund, 2013). Psychomotor development emphasises developing fundamental motor skills such as running, walking, and jumping (Iivonen et al., 2009) and motor coordination (Helder Jose Teixeira Costa, Barcala-Furelos, Abelairas-Gomez,

& Arufe-Giraldez, 2015). The player goal is removed from the enhanced framework due to the similarity with the learning objectives.

3.2.2.2 Learning Content

After defining the learning objective, three modules are proposed for the framework, namely, *Learn with Fun*, *Move Your Body* and *Mind Games*. Each of the modules achieves different learning objectives. *Learn with Fun* focuses on the development of language and communication skills, *Move Your Body* conveys the psychomotor elements to the preschool children, and *Mind Games* fosters the cognitive and psychomotor skill development. The categories, words, motor skills, and exercises used for the aforementioned modules were identified based on the selected Early Childhood Care and Education (ECCE) syllabus (Cecille & Wint, 2010; Damovska, Janeva, Palcevska, Panova, & Shaehu, 2006; GoB & Unicef, 2008) and the survey result obtained from 16 preschools located in the Klang Valley, Malaysia (refer Appendix A). This system can also be reused for revision purposes and for those children who need additional practice. The detailed discussion of each module is available in sections 4.4.1, 4.4.2, and 4.4.3, respectively.

3.2.2.3 Teacher as Advisor

The proposed framework here aims to assist teachers in teaching and assessing preschool children. To further this objective, teachers were involved in the process of system design and development. The teacher acts as an advisor in the learning activity, as depicted in Figure 3.2. Beginning from defining the learning objectives, the teacher gives advice on specifying the learning areas and defining the scope for learning materials that are appropriate for preschool children. After the mapping of learning materials into the respective learning modules, the teacher verifies the learning modules to ensure that the learning objectives are achieved and are matched with the knowledge level of preschool children.

3.2.3 Instruction

Instruction refers to any sequence of events that is intended to assist learning and achieve the desired learning goal (Edwards, Weinstein, Goetz, & Alexander, 2014). Different instructions may lead to different gains. For example, direct instruction is good for teaching reading, writing and motor skill as well as giving feedback to the student but not for teaching problem solving. "*Educational games do not automatically facilitate a wished-for educational outcome, as this is seldom part of either the game universe or the game culture*" (Van Staalduinen & de Freitas, 2011). Therefore, integrating educational instruction into game design has to be done with caution to prevent any feeling of frustration caused by confusing information or unhelpful guidance.

The integration of educational instruction with game elements can ensure the delivering of learning objectives and desired learning outcomes (Garris et al., 2002). Four primary elements of game design are identified for educational purposes, which are context, learner specifics, representation, and pedagogy, as shown in Figure 2.5. Context defines the setting of a game and how it is played. It covers six essential game characteristics that relate to learning, which are fantasy, rules/goals, sensory stimuli, challenge, mystery, and control (Garris et al., 2002). Learner specifics are the learner profile and learning background. Representation includes the interactivity and level of fidelity. Pedagogy refers to the learning models and instructional approaches. The instruction activity lists all the criteria needed for incorporating the instructional content with game elements. It offers a comprehensive guideline for game designer to develop an effective educational game. The instruction activity consists of a game learning cycle which covers the user learning → user behaviour → player feedback → user engagement. The game learning cycle is important for instructional learning where the learner is aware of his/her progress as well as accomplishments in the game through the given feedback (game score or achievement indicator). The learner can achieve the learning objectives through the game learning cycle.

Although the learning activity can assist learning and provide the desired learning goal, lack of participation by the teacher is an insufficiency especially for preschool education. Without the monitoring and control of the teacher, learning issues such as concentration and emotional problems of learners will appear. This will demotivate the learners to continue the GBL.

3.2.3.1 Learning Context and target learner

The enhanced framework retains all the aforementioned game elements and the game learning cycle in the instruction activity. Based on the earlier discussion of learning context (see section 1.3 Statement of Problem), a virtual reality learning environment with real world objects and characters (realistic context) is designed to ease transfer of knowledge for preschool children. Through the virtual reality learning environment, preschool children explore and learn in a realistic context, one where the objects and characters used were created using high fidelity simulation. The proposed framework set the focus on 4 year old preschool children (as mentioned in section 1.5) and the learning material is presented to the target learner via the virtual reality learning environment.

3.2.3.2 Representation of Game

For the representation (interaction/control) of game, voice and gesture interaction are adopted to replace the traditional form of interaction such as mouse, keyboard, and joystick to promote learning. Voice interaction is primarily for preschool children to learn and practice word pronunciation whereas gesture interaction is for psychomotor skill development. The preschool children use speech and gesture commands to communicate, interact and manipulate virtual objects in the game.

3.2.3.3 Pedagogy

The study of pedagogy is essential for linking the game with learning. Three approaches to facilitate the learning — scaffolding, imitation, and trial-and-error, are incorporated to the proposed learning modules for preschool children. Scaffolding is used to support preschool children and prevent the feeling of frustration among the learners. Scaffoldings like hints, visual aids and demonstration are adopted to enhance learning and improve understanding of the learning materials. The use of imitation is effective for the learning of motor skills (Castro-Alonso, Ayres, & Paas, 2014; Paas & Sweller, 2012). Through imitation, the preschool children can learn and improve their bodies' movements to perform the desired motor skill. The trial-and-error approach offers the learning opportunity to consolidate knowledge through mistakes made and result in deeper understanding.

To effectively facilitate preschool learning using GBL, two instructional approaches, the learning model and the transfer model, are proposed for the enhanced framework. These two models decompose the game learning cycle (user learning → user behaviour → player feedback → user engagement) into an iterative learning process. The proposed learning model is aimed to assist the preschool children in the process of acquiring new knowledge and skills. The model is used in *Learn with Fun* and *Move Your Body*. *Mind Games* adopts the transfer model, which allows the preschool children to apply the knowledge and skills in a systematic and structured manner.

Figure 3.3: The proposed learning model

Figure 3.3 is the proposed learning model with two repetitive loops. The first loop begins with learn, practice, feedback, and resume. When the preschool children start their learning, they interact with the system to practice the knowledge and skills that are being taught to them. The system provides corrective feedback according to their responses. There are two types of feedback messages: compliment message and repeat learning instruction. If the correct response is received, a compliment message is shown and the preschool children can continue (resume) their learning of other topics. If the system receives an incorrect response or no response from the preschool children (idle for three seconds), the second loop, which includes learn, practice and feedback (with red arrow), will be triggered. The learning process will start again by repeating the learning instruction for the same topic. The preschool children will repeat their learning and practice for the same topic until the correct response is given. After the compliment feedback is received, the system will allow the preschool children to continue (resume) their learning.

Figure 3.4: The proposed transfer model

Figure 3.4 illustrates the proposed transfer model of enhanced framework. Similarly, the proposed transfer model is an iterative process with two repetitive loops. The first loop begins with process, plan, react, and feedback. The preschool children are required to understand the information/instruction given in an exercise. In this model, they are trained to plan and organise their action in a correct sequence before giving any response. The preschool children can improve their learning through corrective feedback that appears instantly when a response is detected. There are three types of feedback message: compliment message, encouragement message, and repeat instruction. If the correct response is received, a compliment message is shown and the preschool children can continue their exercise or assessment of other topics. If the system receives an incorrect response or no response from the preschool children (idle for three seconds), an encouragement message will display. The second loop, which includes process, plan, and react (with red arrow), will then be triggered. The preschool children will repeat the same instruction for the same activities with some changes in the game instance (object). This model allows the preschool children to use the trial-and-error approach to solve a problem or complete an exercise.

3.2.3.4 Teacher as Facilitator

The teacher acts as a facilitator in the instruction activity, as depicted in Figure 3.2. The teacher decides the time spent on each exercise in the modules based on learning performance. Through observation, the teacher can easily notice any unexpected emotional and concentration problem a child may have during their learning sessions. When the above issues are encountered, the teacher can terminate the lesson and resume later or on other day to prevent negative feelings against learning. In addition, the teacher's judgment is very important to ensure the preschool children are at the right learning pace based on their progress and willingness to learn.

3.2.4 Assessment

"*Assessment is a broad, comprehensive process, not any specific activity or technique*" (Lidz, 2002). It can appear in various forms, either in the form of paper test, experiment, or evaluation. Each type of assessment measures a different set of learning outcome. In GBL, adequate and immediate system feedback given to the students is very useful because it facilitates the development of mental models and schemata and thus improves expertise and expert performance (Ifenthaler et al., 2012). Assessment aims to measure the transfer of knowledge, and reflect the understanding of knowledge as well as the mastery of language, cognitive and psychomotor skill. The use of multiple forms of assessment can offer more detailed information on the achievements of a learner in various aspects.

The assessment activity in the original framework includes debriefing and system feedback. Debriefing refers to the discussion between teacher and learner after the game session while system feedback is the game score obtained in a game assessment. For preschool learning, the debriefing is modified become simple conversation or question-and-answer (Q & A). Through simple conversation, the teacher gives feedback or explanation to the preschool children to help them understand their learning progress and achievement. Moreover, the teacher can identify the area of improvement via Q & A. Without the full participation of teacher in the process of assessment, the quality of result is questionable because the preschool children might not be assessed correctly or comprehensively.

3.2.4.1 Proposed Assessments

The enhanced framework proposes two types of assessments: *Physical Game Assessment* and *Virtual Game Assessment*. These two assessments are grouped under assessment modules and used to evaluate the language and communication, cognitive and psychomotor development of the learner. *Physical Game Assessment* is an evaluation of preschool children's learning outcomes via classroom games. The evaluation is done through a simple conversation or question and answer. The evaluation is important to ensure the preschool children can form a connection to what they learn with the real world situation to ease the transfer of knowledge. The classroom games that are relevant with the assessment scope such as catch/throw a ball, building blocks, puzzle, and card game are selected for evaluation purposes. The preschool children are assessed individually for all the games regardless of the game setting (individual play or group play).

Virtual Game Assessment is used to evaluate the knowledge transfer of the preschool children via the virtual learning environment (VLE). The VLE includes some assessment activities that require gesture interaction in a media rich environment such as body part recognition (*Magic Tree*), number game (*Open Sesame*), and problem solving (*Forest Adventure*). The preschool children will be asked to use gestures such as touching, jumping and hopping, to solve a problem or challenge in the above-mentioned activities. The details of the activities are discussed in section 4.5.

3.2.4.2 Teacher as Evaluator

The teacher acts as an evaluator in the assessment activity, as depicted in Figure 3.2. Beginning from giving advice on specifying the areas and the scope for assessment, the teacher suggests the modes of assessment that are suitable for preschool children. The teacher will decide on the right time for each child to take the assessment and the duration for each assessment. Apart from this, the teacher can terminate and resume the assessment depending on the readiness of the preschool children. This is to ensure that each child can be assessed effectively and not be affected by emotional and concentration issues.

In the *Physical Game Assessment*, the teacher can know about the children's understanding of the taught topic and/or skills when they are engaged with a game. Through a simple conversation or Q & A, the teacher can easily find out the skills that have been mastered by the children. In the *Virtual Game Assessment*, teacher can discover the challenges faced by each child in completing an activity in the game such as follow instruction, process information, and choosing the right answer. This observation is very useful for understanding a child's learning outcome and to effectively assist him in improving his learning.

The collected data from both the assessments can be used to understand the learning progress of preschool children. The teacher can use the data to analyse the area that is needed for improvement. The teacher can then give additional training or exercises for the identified area to improve transfer of knowledge. The teacher can also decide to increase the time for learning and practice individually, for those children who are weak.

3.2.5 Survey for the Proposed System

The appropriateness of content can affect interest and progress of learning. Martinovic et al. (2016) highlighted that the age-appropriateness of game activities can foster children's learning. Two surveys were designed to gather information for system design and development purposes. One survey was conducted to determine the scope of learning and types of assessment for aged 4 children (see Appendix A) whereas the other one was used to gather teacher feedback for the system prototype (see Appendix B).

3.2.5.1 The development of questionnaires and tests

A survey to identify the scope of learning and types of assessment for 4 years old children was conducted. A four-page questionnaire that consisted of fourteen questions was used to collect user requirements for the designing of the prototypes for learning and assessment modules (refer to Appendix A). Mixed questionnaire, which consist of closed and open-ended questions was used to gather the opinion and suggestion of the participant on the scope of learning and types of assessment for 4 years old children.

The first two questions were designed to gather information about a participant's professional background such as job position and teaching experience. This information is needed to ensure the validity of participants' answers. The third to seventh questions determined the scope of learning in the areas of language and communication, cognitive, and psychomotor skills. Multiple choices questions were used to allow the participant to select more than one answer. The choices provided in the third to seventh questions are based on the ECCE syllabus (Cecille & Wint, 2010; Damovska et al., 2006; GoB & Unicef, 2008). The remaining questions helped to determine the proper instruments to be used for assessments.

A pre-test was developed to evaluate prior knowledge of preschool children. The pre-test includes language and mathematics test, and motor skill tests. The pre-test, comprised of twenty questions, covers the topic of body part, colour, shape, and number (refer to Appendix D). There are a total of eleven motor skills to be assessed in the motor skill test, covering body balance, object control (catching/throwing ball) and locomotor skills (i.e. running, kicking, jumping, and hopping) (refer to Appendix E). The motor skill test is modified based on the Test of Gross Motor Development, Second Edition (TGMD-2) (Ulrich, 2000).

The post-test consists of two assessments: *Physical Game Assessment* and *Virtual Game Assessment*. It was used to examine the performance of preschool children in the areas of language and communication, cognitive, and psychomotor development. *Physical Game Assessment* assesses their knowledge transfer and psychomotor skills through physical games (i.e. puzzle and games) whereas *Virtual Game Assessment* evaluates the preschool children's learning outcomes via virtual learning environment (VLE). These two assessments are used to analyse the effectiveness of the virtual learning context in knowledge transfer for preschool children. All the assessments are designed based on the proposed syllabus in the learning modules.

There are seven assessments in *Physical Game Assessment —Building Blocks*, *Card Game*, *Counting Game, Puzzle*, *Question and Answer* (*Q & A*) *Game*, *Ball Skills*, and *Leg Game*. *Building Blocks* is used to evaluate the preschool children's recognition of colours and shapes, decision-making, problem solving and psychomotor skills (hand-eye coordination). *Card Game* is used to examine word recognition for colours, shapes, and numbers. *Counting Game* assesses the preschool children's counting skills. *Puzzle* tests them on word recognition for human body part while *Q & A Game* evaluates their communication skills. *Ball Skills* and *Leg Games* are used to evaluate psychomotor skills related with hands and legs. Table 3.1 summarises the associated skills assessed by the *Physical Game Assessment*.

Table 3.1: Mapping of Language and Communication, Cognitive, and Psychomotor Skills for *Physical Game Assessment*

	Language and Communication		Cognitive			Psychomotor	
	Speech	Vocabulary	Recognition skill	Decision -making skill	Problem solving skill	Coordination	Attention / focus
Building Blocks (*Colour & Shape*)			✓	✓	✓	✓	✓
Card Games (*Colour, Shape, & Number*)		✓	✓				
Counting Games (*Number*)	✓			✓	✓	✓	✓
Puzzle (*Body Part*)		✓	✓				
Q & A Game (*Body Part*)	✓	✓					
<u>Ball Skills</u> **Ball Catching/ Throwing**						✓	✓
Ball Passing (Kicking)						✓	✓
<u>Leg Games</u> **One leg stand**						✓	✓
Running						✓	✓
Jump forward & backward						✓	✓
Hop forward & backward						✓	✓

There are five sub-modules in *Virtual Game Assessment* —*Body Journey* (*Body Quiz*, *Magic Tree*, and *Fix Me*), *Colour World* (*Colour Quiz* and *Ball Game*), *House of Shape* (*Shape Quiz* and *Keep the Toys*), *Number Hut* (*Number Quiz*, *Open Sesame*, and *Let's Count*),and *Treasure Hunt* (*Forest Adventure*, *River Adventure*, and *Treasure Box*). *Body Quiz* is used to evaluate recognition of human body parts; *Colour Quiz* is used to examine the capacity to differentiate colours; *Shape Quiz* assesses knowledge of various shapes; and *Number Quiz* tests number recognition and counting skills. Cognitive skills such as problem solving skills are examined via *Magic Tree* (*Body Journey*), *Fix Me* (*Body Journey*), *Open Sesame* (*Number Hut*), and *Let's Count* (*Number Hut*) whereas decision-making skills are assessed through *Ball Game* (*Colour World*) and *Keep the Toys* (*House of Shape*). *Treasure Hunt* is used to evaluate the preschool children's psychomotor skills. Within this sub-module, *Forest Adventure* examines the running, kicking, hopping and balance skills; *River Adventure* evaluates the jumping, catching, and throwing skills; and *Treasure Box* tests the pushing and pulling skills. Table 3.2 and 3.3 summarise the mapping of cognitive and psychomotor skills assessed in each sub-module in the *Virtual Game Assessment*.

Table 3.2: Mapping of Cognitive Skills for *Virtual Game Assessment*

Cognitive Skill	**Body Journey**			**Colour World**		**House of Shape**		**Number Hut**		
	Body Quiz	Magic Tree	Fix Me	Colour Quiz	Ball Game	Shape Quiz	Keep the toys	Number Quiz	Open Sesame	Let's Count!
Recognition/ memorisation skill	✓			✓		✓		✓		
Decision-making skill					✓		✓			
Problem solving skill		✓							✓	

Table 3.3: Mapping of Psychomotor Skills for *Virtual Game Assessment*

Psychomotor Skill	Treasure Hunt							
	Forest Adventure			River Adventure			Treasure Box	
Fundamental motor skills	Run ✓	Kick ✓	Hop ✓	Jump ✓	Catch ✓	Throw ✓	Push ✓	Pull ✓
Recognition/ memorisation skill					✓	✓		
Decision-making skill	✓			✓			✓	✓
Problem solving skill		✓	✓		✓	✓		

Two prototypes were developed based on the information provided by the first survey on content and assessment. The first prototype consists of three learning modules (*Learn with Fun*, *Move Your Body*, and *Mind Games*) while the second prototype was designed for *Virtual Game Assessment*, which comprises five game-based assessment modules (*Body Journey*, *Colour World*, *House of Shape*, *Number Hut*, and *Treasure Hunt*).

A survey was conducted to collect the feedback from teachers for the developed prototypes and proposed assessment, *Physical Game Assessment*. A six-page questionnaire consisting of twelve questions was used to collect each teacher's comment or suggestion (refer to Appendix B). The participants who completed the second survey were the same participants as those in the first survey. Rating Scale questions were used to measure the feedback for the developed prototypes.

The first question is designed to examine the appropriateness of the exercises for the proposed system. It consists of three sub-questions to allow the participants to evaluate each learning module (*Learn with Fun*, *Move Your Body*, and *Mind Games*) separately.

The second question is for the organisation of the content in learning modules. Similarly, the participants evaluate each learning module separately via three sub-questions. The third question aims to inspect the usefulness of the learning modules and again, there are three sub-questions in each module. The fourth question is used to seek the teacher's opinion on the children's engagement based on the demonstration of the prototype.

The fifth question is designed to examine the appropriateness of the assessments for *Virtual Game Assessment*. Likewise, the sixth, seventh, and eighth questions investigate the organisation of the assessments, usefulness of the assessment modules, and the teacher's opinion on the children's engagement. Similarly, each question comprises five sub-questions to allow participants to evaluate each sub-module individually (*Body Journey*, *Colour World*, *House of Shape*, *Number Hut*, and *Treasure Hunt*).

The remaining four questions are for the evaluation of the appropriateness, organisation, and usefulness of the assessments as well as the teacher's opinion on children's engagement for the *Physical Game Assessment*. Each question comprises seven sub-questions to allow the participants to evaluate each sub-module specifically (*Building Blocks*, *Card Game*, *Counting Game, Puzzle*, *Question and Answer* (*Q & A*) *Game*, *Ball Skills*, and *Leg Game*).

3.2.5.2 The reliability and validity of surveys and tests

As a general rule, a sample size of 30 and above can be accepted as an approximately normal sampling distribution (Horng-Jinh, Kuo-Chung, & Chao-Hsien, 2006). Thus, the sample size of 32 was used to collect the information regarding the learning scope and assessment methods (first survey) for children aged 4. All the participants volunteered to participate in this survey. The survey was conducted individually for confidentiality purposes. All responses were recorded and analysed after the participants completed every question and returned their respective questionnaires.

Each of the questions in the questionnaire was reviewed and revised before being distributed to the participants. The aim of the review was to prevent any ambiguity and to ensure the response options were valid and mutually exclusive (no overlapping). Then, a pilot survey was conducted on 10 participants from 5 kindergartens located in the Klang Valley, Malaysia, to examine the reliability of the questionnaire in order to achieve the objectives. After that, the questionnaire was given to another 22 participants from 11 kindergartens in the Klang Valley. All the participants must at least have 1 year of teaching experience in kindergarten to ensure the validity of participants' answer.

The same procedure as the first survey was repeated for the second, including the pilot survey and the sample size used. The survey was conducted individually for confidentiality purposes and a demonstration of the developed prototypes (learning and assessment modules) was shown to each participant before they could answer the questions.

There are two tests, which are pre-test and post-test, used for this study. The pre-test was reviewed by two kindergarten teachers with at least 5 years of preschool's teaching experience. The post-test consists of *Physical Game Assessment* and *Virtual Game Assessment*. All the assessments are designed based on the approved syllabus used in the learning modules and verified by 32 teachers from 16 kindergartens in the Klang Valley, Malaysia.

3.2.6 System Design and Implementation

The revised prototypes were integrated into a workable system to achieve the second research objective. There were two stages involved in the integration process, which were system design and implementation stage. Each module was checked and tested completely with its set objectives and followed by the system integration testing. The proposed system was then used as a tool for teaching the knowledge to the preschool children and also for evaluating their learning performance.

The system design consists of system architecture, underlying system mechanisms, graphical user interface (GUI), user interaction process, and data storage. The system architecture and respective system mechanism were explained using diagram and flow charts. A standard interface and interaction process were used for the proposed system to ease the teacher and children into learning. All the involved activities and logics were presented using pseudocode. The children's learning performance is recorded and presented in a report card format. A web browser is used to view the children's report card (assessments' record) and Extensible Mark-up Language (XML) is used for storing and transport data. A storage manager is used to handle the data query, accessing and storing.

The proposed system is developed using .NET C# running on Visual Studio 2012. It is a standalone system that runs on Xbox Kinect console (somatosensory platform). The learning and assessment modules are the two main modules in the proposed system. The learning modules comprise three sub-modules (*Learn with Fun*, *Move Your Body*, and *Mind Games*) whereas the *Virtual Game Assessment module* consists of five sub-modules (*Body Journey*, *Colour World*, *House of Shape*, *Number Hut*, and *Treasure Hunt*). Each module differs with each other in GUI design, interaction process (gesture or voice recognition), as well as the functional and non-functional requirements based on the set objectives. The gesture and voice recognition features are introduced into the learning process. This intuitive interaction not only reduces the frustration caused by the use of mouse or controller but also offers a new learning experience for the children. Besides, feedback and scaffolding are designed to assist the preschool children in learning. The feedback includes giving compliments for correct responses and encouragement for incorrect responses as well as the assessment result. The preschool children are supported via demonstration and visual aids (imitation) and repeat learning instruction. Moreover, trial-and-error approach is used to allow the preschool children to learn from mistakes and encourage them to continue solving a problem until they get the correct answer/solution. This approach can also improve their understanding of a particular topic.

3.2.7 System Testing and Evaluation

Several tests were conducted for the proposed system before it was evaluated in order to achieve the third objective. The system testing focused on speech and gesture recognition and system integration. Speech recognition testing aimed at deciding the best acceptance level of speech recognition without losing the clarity. The gesture recognition testing was to examine the capability of the skeletal tracking function in tracking the movement of 4 year old children. The last testing was system integration testing. This testing aimed to ensure the proposed learning system fulfilled the specified requirements as a learning and assessment tool for 4 year old children.

The evaluation of proposed framework helps the teachers to evaluate the potential of using GBL in their practice. The proposed framework was evaluated using four-dimensional framework in the dimension of context, learner specification, pedagogic considerations, and mode of representation (De Freitas & Oliver, 2006). In brief, context refers to where learning occurs and availability of resources and tools. Learner specification is to identify the target learner such as age and learning preferences. Pedagogic considerations focus on pedagogic approaches that used to support learning practice. Lastly, mode of representation means the interactivity and fidelity of simulation.

Teachers from participated kindergartens were invited to take part in the intervention program that conducted in respective kindergartens. At the end of the intervention program, a survey and an interview are used to collect the feedback from the teachers to evaluate the capacity and ability of the proposed framework in assisting teachers in teaching and assessing preschool children.

For system evaluation, a pre-test and post-test evaluation is used to evaluate the performance of preschool children's learning in terms of language and communication, cognitive, and psychomotor development. A GBL intervention program was conducted in six selected preschools (kindergartens) from December 2014 to March 2015 using the proposed system. The intervention program was conducted for 4 weeks, 5 days per week, and each day 40 minutes. A total of 84 preschool children aged 4 were invited to participate in the intervention program. Simple background information such as race, gender, family's language, enrolled age, weight, and height was taken for data analysis purposes. Figure 3.5 illustrates the execution procedure of the intervention program.

First, all the participated children sat for a pre-test that held at their kindergartens. The pre-test consists of two tests: language and mathematics test, and motor skill tests. The language and mathematics test consists of twenty questions (refer to Appendix D). This test is to examine the knowledge of the participants. Each correct answer will be awarded 1 mark and total mark is 20.

After that, all the participants attended the motor skill test (refer to Appendix E). There are a total of eleven motor skills to be assessed in the test, covering body balance, object control (catching/throwing ball) and locomotor skills (i.e. running, kicking, jumping, and hopping). Each correct demonstration will be awarded 1 mark with the total marks being 11. All the tests were accompanied by the kindergarten teachers. Teachers were allowed to assist those children who had problems following the instructions. However, they were prohibited from giving any clue that might help the children find the right answer or assist them in performing the requested motor skill.

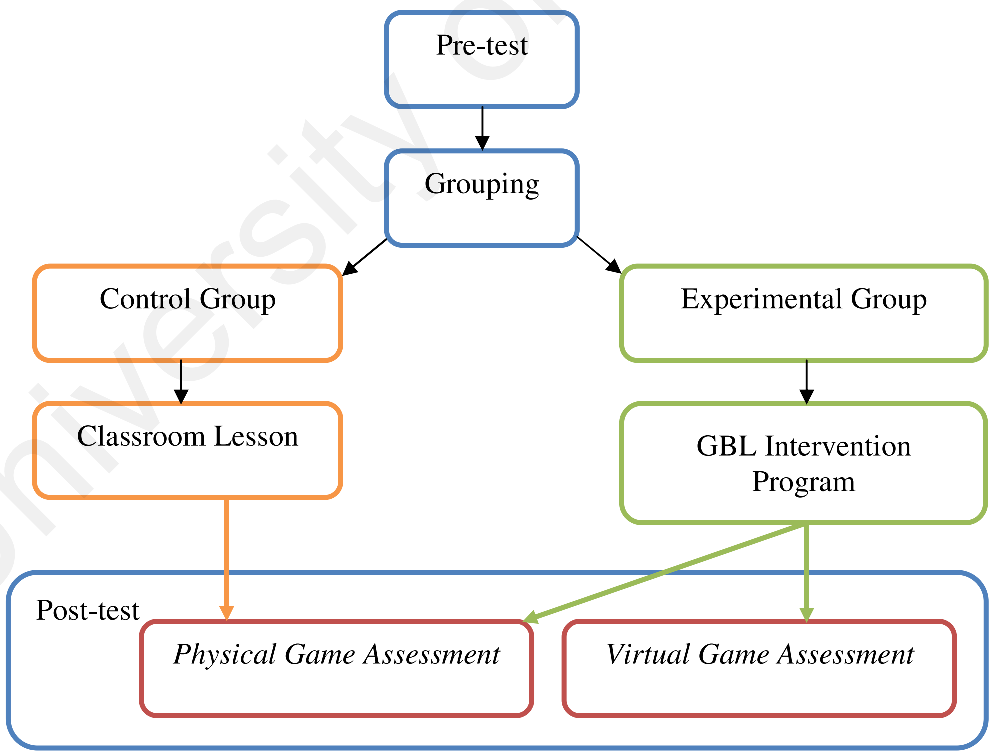


Figure 3.5: Flow of intervention program

After the pre-test, the children's score was calculated and converted to 100% by using equation 3.1.

$$c = [(\frac{a}{p})\ 0.5 + (\frac{b}{q})\ 0.5] \times 100\% \qquad (3.1)$$

Where c = final score of pre-test,

a = mark scored for language and mathematic test,

p = 20, total mark of language and mathematic test,

b = mark scored for motor skill test, and

q = 11, total mark of motor skill test

For example, if a child scored 12 marks in language and mathematic test and 8 marks in motor skill test, the calculation of final score for pre-test will be as follow:-

c = [(12 /20) 0.5 + (8 /11) 0.5] x 100% = 66%

The weightage was discussed and accepted by the majority of the participants who took part in the first and second surveys. The children were divided into three categories, *Excellent*, *Average*, and *Low Performance*, based on their calculated mark. Children who scored 80 and above were grouped in the category named *Excellent Performance*, those who scored between 50 and 70 were in the group *Average*, and those who had a total mark below 50 fell under the *Low Performance* category. Table 3.4 summarises the grading scheme.

Table 3.4: Grading Scheme

Total Mark	Category
80 – 100	*Excellent Performance*
50 – 79	*Average Performance*
0 – 49	*Low Performance*

After that, the children in each category were randomly divided into two groups, the control group and the experimental group. The control group followed the existing classroom lesson whereas the experimental group joined the intervention program. This grouping aimed to investigate the effectiveness of the proposed system for children at different level of learning performance. Besides, it also allowed the comparison of their learning performance before and after participating in the intervention program.

After the intervention program was completed, the control group sat for *Physical Game Assessment* whereas the experimental group attended both the *Physical Game Assessment* and *Virtual Game Assessment*. Equation (3.2) is used to calculate the final score of *Physical Game Assessment* for the comparisons between pre-test whereas equation (3.3) is used to compare the performance between control group and experimental group children. The pre-test did not include the *Building Blocks* and *Q & A Game* assessments, thus *C1* and *L3* are removed from the equation (3.2). Besides, same weightage as equation (3.1) is used. Similarly, the weightage used and the category of assessed skill were based on the discussion and approval by the majority of the participants who took part in the first and second surveys. Both the calculated scores are used for data analysis and comparison purposes. Table 3.5 summarises the mark allocation for each assessment in *Physical Game Assessment*.

Table 3.5: Marking Scheme for *Physical Game Assessment*

Physical Game Assessment	*Building Blocks (C1)*	*Counting Game (C2)*	*Card Game (L1)*	*Puzzle (L2)*	*Q & A Game (L3)*	*Ball Skills (P1)*	*Leg Game (P2)*
Mark	18	5	15	5	10	3	8
Category	Cognitive skill		Language and communication skill			Psychomotor skill	

$$d = [(\frac{C2+L1+L2}{r})\ 0.5 + (\frac{P1+P2}{s})\ 0.5] \times 100\% \quad (3.2)$$

$$h = [(\frac{L1+L2+L3}{w})\ 0.4 + (\frac{C1+C2}{y})\ 0.3 + (\frac{P1+P2}{z})\ 0.3] \times 100\% \quad (3.3)$$

Where d, h = final score of post-test,

C1, C2 = mark gained for cognitive skill,

L1, L2, L3 = mark gained for language and communication skill,

P1, P2 = mark gained for psychomotor skill,

r = 25, total mark of language and mathematic skill,

s = 11, total mark of psychomotor skill,

w = 30, total mark of language and communication skill,

y = 23, total mark of cognitive skill, and

z = 11, total mark of psychomotor skill

Table 3.6 show the examples calculation for the result of two children: one from control group and the other one from experimental group. Equation (3.2) is used to calculate the comparison between pre-test and *Physical Game Assessment*.

Table 3.6: Example of post-test result for control and experimental group's children

Physical Game Assessment	*C1*	*C2*	*L1*	*L2*	*L3*	*P1*	*P2*
Child A (control group)	15	3	12	4	6	3	7
Child B (experimental group)	12	4	13	4	6	2	6

If child A (control group) scored 60% for pre-test, then the post-test score (*Physical Game Assessment*) will be calculated as below:-

Post-test score (child A) = [((3+12+4)/25)0.5 + ((3+7)/11) 0.5] x 100% = 83%

Difference in two test = (83% - 60%)/60% x 100% = 38.33%

If child B (experimental group) scored 60% for pre-test, then the post-test score (*Physical Game Assessment*) will be calculated as below:-

Post-test score (child B) = [((4+13+4)/25)0.5 + ((2+6)/11) 0.5] x 100% = 78%

Difference in two test = (78% - 60%)/60% x 100% = 30%

To compare the post-test score between control group and experimental group, equation (3.3) is used.

Post-test score (child A) = [((12+4+6)/30)0.4 + ((15+3)/23) 0.3+ ((3+7)/11) 0.3] x 100%

= 79%

Post-test score (child B) = [((13+4+6)/30)0.4 + ((12+4)/23) 0.3+ ((2+6)/11) 0.3] x 100%

= 74%

Table 3.7: Marking Scheme for *Virtual Game Assessment*

Virtual Game Assessment	Mark allocated	Skill Assessed
Body Journey		
Body Quiz (L1)	5	Language and communication skill
Magic Tree(C1)	3	Cognitive skill (Problem solving)
Fix Me (C2)	2	
Colour World		
Colour Quiz (L2)	5	Language and communication skill
Ball Game (C3)	5	Cognitive skill (Decision-making)
House of Shape		
Shape Quiz (L3)	5	Language and communication skill
Keep the Toys (C4)	5	Cognitive skill (Decision-making)
Number Hut		
Number Quiz (L4)	5	Language and communication skill
Open Sesame (C5)	2	Cognitive skill (Problem solving)
Let's Count (C6)	3	
Treasure Hunt		
Forest Adventure (*Run*, *Kick*, *Hop*, and *Balance*) (P1)	4	Psychomotor skill
River Adventure (*Jump*, *Catch*, and *Throw)*(P2)	3	
Treasure Box *(Push and Pull)*(P3)	2	

Table 3.7 summarises the mark allocation for each assessment in *Virtual Game Assessment*. Equation (3.4) is used to calculate the final score of *Virtual Game*

Assessment for the comparisons between pre-test whereas equation and (3.5) is used to compare the performance within the experimental group children. The pre-test did not include the evaluation of *Push* and *Pull*, thus P3 is removed from the equation (3.4). Similarly, the weightage used and the category of assessed skill were based on the discussion and approval by the majority of the participants who took part in the first and second surveys.

$$s = [(\frac{L1 + L2 + L3 + L4}{j})\ 0.4 + (\frac{C1 + C2 + C3 + C4 + C5 + C6}{k})\ 0.3 + (\frac{P1 + P2}{l})\ 0.3] \times 100\% \quad (3.4)$$

$$v = [(\frac{L1 + L2 + L3 + L4}{j})\ 0.4 + (\frac{C1 + C2 + C3 + C4 + C5 + C6}{k})\ 0.3 + (\frac{P1 + P2 + P3}{t})\ 0.3] \times 100\% \quad (3.5)$$

Where s, v	= final score of post-test,
L1, L2, L3, L4	= mark gained of language and communication skill,
C1, C2, C3, C4, C5, C6	= mark gained of cognitive skill,
P1, P2, P3	= mark gained of psychomotor skill, and
j	= 20, total score of language and communication skill
k	= 20, total score of cognitive skill, and
l	= 7, total score of psychomotor skill
t	= 9, total score of psychomotor skill

Table 3.8 show an example result for *Virtual Game Assessment.* Equation (3.4) is used to calculate the comparison between pre-test and *Virtual Game Assessment*.

Table 3.8: Example of result calculation for *Virtual Game Assessment*

Virtual Game Assessment	*C1*	*C2*	*C3*	*C4*	*C5*	*C6*	*L1*	*L2*	*L3*	*L4*	*P1*	*P2*	*P3*
Child C (experimental group)	3	2	4	4	2	3	5	4	4	5	4	3	2

If child C (experimental group) scored 60% for pre-test, then the score for *Virtual Game Assessment* will be calculated as below:-

Score (child C) = [((5+4+4+5)/20)0.4 + ((3+2+4+4+2+3)/20) 0.3+ ((4+3)/7) 0.3] x 100%

= 93%

Difference in two test = (93% - 60%)/60% x 100% = 55%

For comparison within experimental group and between *Physical Game Assessment*, equation (3.5) is used. The example calculation is as below:-

Score (child C) = [((5+4+4+5)/20)0.4 + ((3+2+4+4+2+3)/20)0.3+ ((4+3+2)/9)0.3]x100%

= 93%

Table 3.9: Data Analysis Techniques Used to Evaluate the Proposed System

No.	Purpose	Data Analysis Techniques	Information Gained
1	To examine the normality of the sample	Shapiro-Wilk Test	Statistical results on sample distribution
2	To evaluate the children's learning performance	Analysis of variance (ANOVA), multivariate analysis of variance (MANOVA), pairwise comparison	Statistical results for the comparisons of children's learning performance by group, gender, and level of performance
3	Association between areas of children development	Pearson Correlation and regression analysis	Statistical results on the association between areas of development, knowledge, and skills

Table 3.9 summarises all the data analysis techniques used to evaluate the effectiveness of the proposed system in achieving the third objective. The overall performance of two groups of children were analysed through analysis of covariance (ANCOVA), pairwise comparison, and multivariate analysis of covariance (MANOVA). ANOVA examines the differences in the group means whereas ANCOVA looks for differences in adjusted means (i.e. pre-test). The purpose of using the pre-test result as a covariate in ANCOVA

with a pretest-posttest design is to reduce the error variance (Dimitrov & Rumrill Jr, 2003). MANOVA was used to examine the interaction effect between groups, gender, and level of performance (*Excellent*, *Average*, and *Low*) in the areas of development (language and communication, cognitive, and psychomotor skills). Pearson correlation and regression analyses were used to find the relationship between each area of development such as language and communication, cognitive, and psychomotor skills.

A two-page questionnaire consisting of seventeen questions was used to collect the teacher's feedback (refer to Appendix C) on using the proposed system in teaching and assessing the preschool children. The participants who completed the survey were the same participants as those in the previous surveys. The questions used in the questionnaire are summarized in Table 3.10.

Table 3.10: Summary of questionnaire for teacher's feedback

Learning Module	
Question 1	Examine the organisation and ease of use of the learning modules.
Question 2	Inspect the usefulness of the menu navigation function and the third question is about the easiness to terminate the module.
Question 3	Examine the easiness to terminate the module.
Question 4	Investigate the helpfulness of the learning modules for teaching the preschool children.
Question 5	Examine the effectiveness of the instruction, visual aids and demonstration (scaffolding) and feedback.
Question 6	Investigate the acceptance of the proposed system in teaching.
Physical Game Assessment	
Question 7	Examine the organisation and ease of use of the *Physical Game Assessment*.
Question 8	Inspect the usefulness of the marking scheme.
Question 9	Inspect the helpfulness of the assessment modules for assessing the preschool children.
Question 10	Investigate the teacher's opinion for having the opportunity to observe how the children completing their assessment.
Question 11	Investigate the acceptance of this module in assessing preschool children.
Virtual Game Assessment	
Question 12	Examine the organisation and ease of use of the *Virtual Game Assessment*.
Question 13	Evaluate the usefulness of the menu navigation function.
Question 14	Evaluate the easiness to terminate the module.
Question 15	Inspect the helpfulness of the assessment modules for assessing the preschool children.
Question 16	Investigate the usefulness of report card.
Question 17	Examine the willingness to adopt the assessment module in assessing preschool children.

Each of the questions in the questionnaire was reviewed and revised before distribution to the participants. The aim of the review was to prevent any ambiguity and to ensure the response options were valid and mutually exclusive (no overlapping). The same procedure as the previous surveys was repeated for this survey including the pilot survey and the sample size used. All the participants were volunteers. The survey was conducted individually for confidentiality purposes. All responses were recorded and analysed after questionnaires were completed and returned.

3.2.8 Documentation

All the procedures involved in the literature review, research methodology, system design and implementation, and the findings of the research, were documented in this thesis at the end of the research. The proposed framework, results analysis, and significant findings including the experiences gained via the system design and implementation, were submitted as articles in several journals.

3.2.9 Summary

This chapter explained the methodology used for this research. The flow of research methodology described the essential approaches adopted for information and user requirement gathering, system design and implementation, and system testing and evaluation. Besides, the proposed framework and the data gathering and analysis used in various development phases were discussed in detail.

The proposed GBL framework for preschool learning aimed to increase the involvement of teachers in the activities of learning, instruction, and assessment. The teacher acts as an advisor for the mapping of learning content with the learning objectives, a facilitator for implementing instructional learning in the classroom, and an the evaluator for the assessment. The participation of teacher in the GBL encourages the use of technology in the school curriculum and improves the experience of using game for teaching and assessment. Moreover, the time spent on preparing the learning and assessment materials was reduced because the teacher can rely on the GBL system to deliver the learning content and assist the preschool children to learn through scaffolding and feedback. Concerns about irrelevant or mismatch of games and curriculum content were overcome by allowing the teacher to verify the content for learning and assessment. Furthermore, the teacher can use it to engage preschool children in the learning, thanks to the virtual interactive learning environment.

The next chapter presents the system design and implementation of the proposed system in details. The discussion begins with the system requirement analysis followed by the system architecture and design, as well as the functionality of each module in the proposed system.

CHAPTER 4:System Design and Implementation

4.1 Introduction

This chapter explains the requirement analysis, system architecture and design, as well as the functionality of learning system. The surveys' result on teachers' feedback for content and system prototype is explained in requirement analysis. The system architecture and design gives an overview on how the GBL system is developed and implemented. After that, the chapter discusses the learning system from the aspects of content design, representation of game, and respective learning models with the aid of GUI (Graphical User Interface) and pseudocode.

4.2 System Requirement Analysis

The results from the survey on the scope of proposed system and developed prototype are discussed in section 4.2.1 and 4.2.2 respectively.

4.2.1 Result for the Survey on the Scope of Proposed System

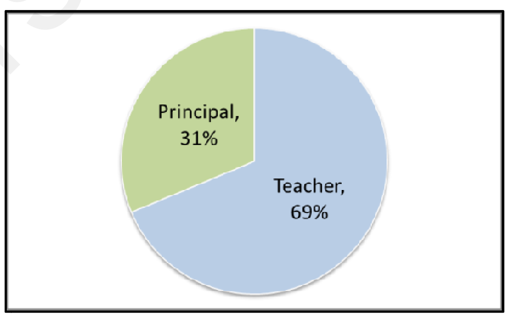


Figure 4.1: Work position of participants

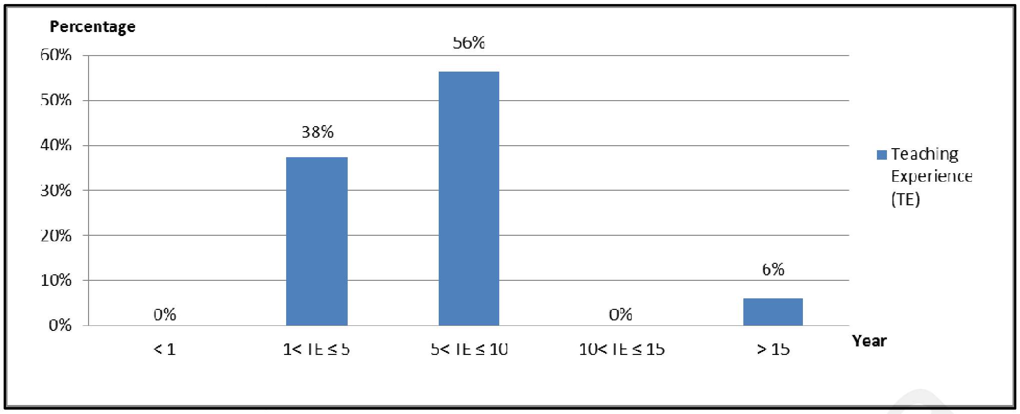


Figure 4.2: Participants' years of teaching experience

There were a total of 32 participants who took part in the survey. 22 participants (69%) were kindergarten teachers and the remaining 10 persons were principals (31%) (see Figure 4.1). Figure 4.2 shows the number of years of teaching experience of participants. Overall, 62% of the participants have had more than 5 years teaching experience. The remaining 38% fell between 1 to 5 years teaching experience. The results showed that most of the participants have experience and are familiar with preschool education.

Based on teacher feedback, a syllabus was proposed for the learning modules to promote language and communication, cognitive and psychomotor development of 4 years old children. Figures 4.3, 4.4, 4.5, and 4.6 show responses to the words to be learned that are related with Body Part, Colour, Shape, and Number, respectively. Words with a response rate above 80% were selected because they were accepted and agreed upon by most of the participants as those expected to be learned by 4 year old children in general. Table 4.1 summarises the words selected based on responses of the survey.

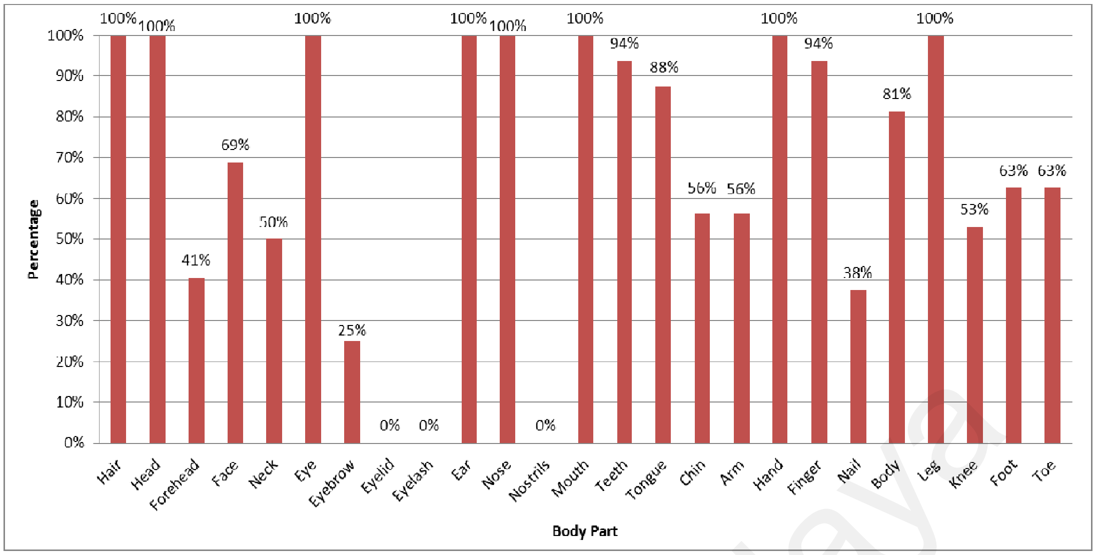


Figure 4.3: Response for Body Part vocabulary

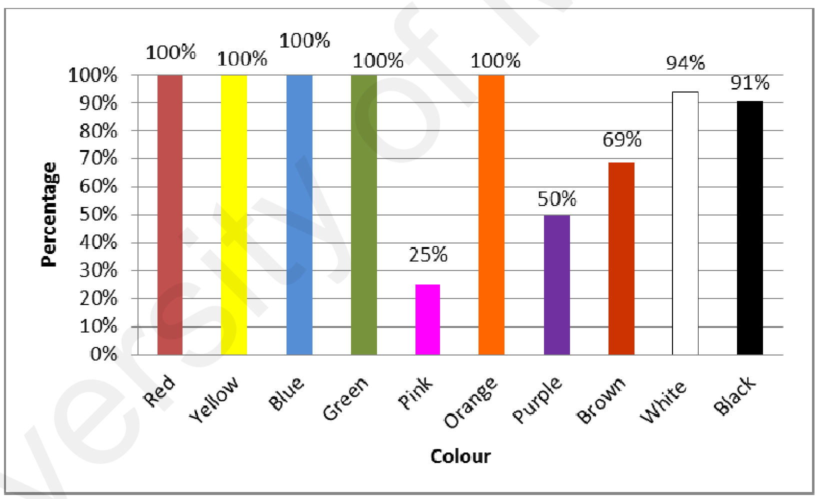


Figure 4.4: Response for Colour vocabulary

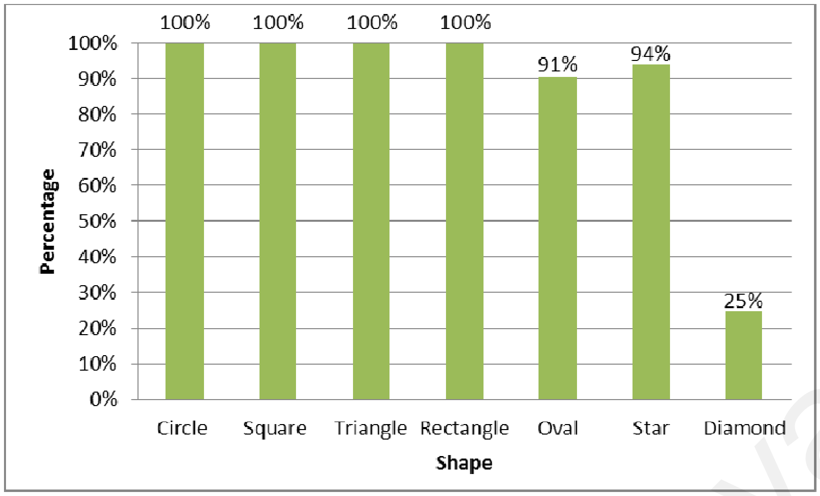


Figure 4.5: Response for Shape vocabulary

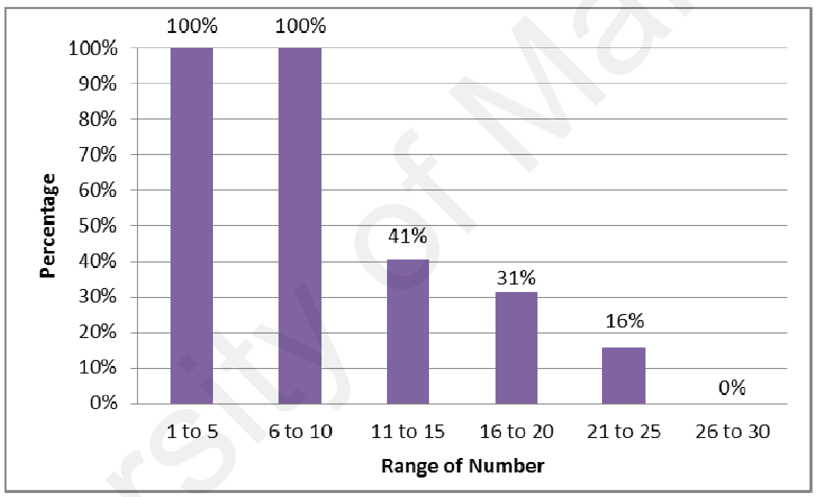


Figure 4.6: Response for Number range

Table 4.1: Recommendation of Vocabulary Learning for Age 4 Children

Body Part		Colour	Shape	Number	
Hair	Tongue	Black	Circle	One	Six
Head	Teeth	Red	Square	Two	Seven
Eye	Body	Orange	Rectangle	Three	Eight
Nose	Leg	Yellow	Triangle	Four	Nine
Ear	Hand	Green	Oval	Five	Ten
Mouth	Finger	Blue	Star		
		White			

Responses for the motor skills that should be learned by children aged 4, are depicted in Figure 4.7. The motor skills with a response rate above 80% were selected since this meant that they were commonly accepted and agreed upon by most of the participants. According to the participants, sliding (38%), galloping, and skipping are less appropriate for children at age 4. Apart from these, they also suggested warming up exercises including moving the head, hands, and legs. Table 4.2 summarises the selected motor skills based on the responses in the survey.

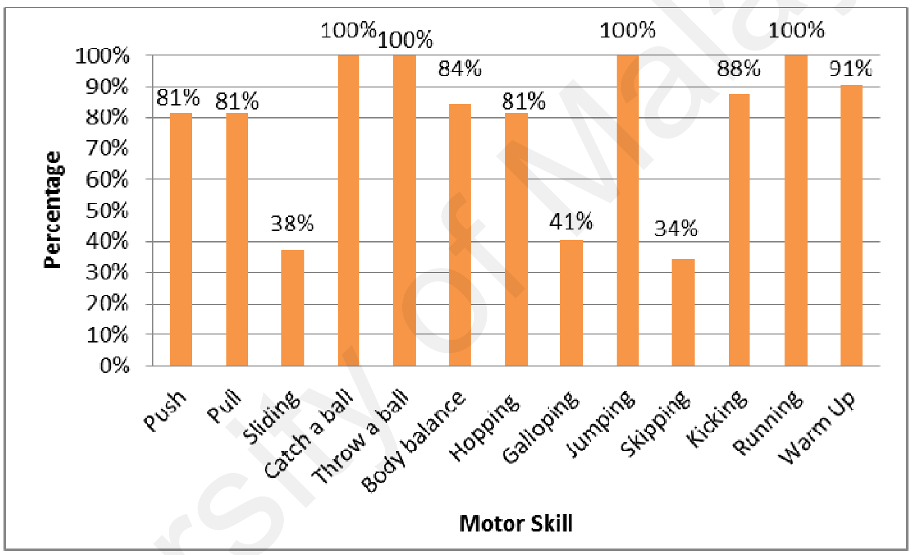


Figure 4.7: Response for Motor Skills

Table 4.2: Recommendation of Motor Skills Learning for Age 4 Children

Warm Up Skills	Body Balance	Hand Skills	Legs Skills
Head Hands and Legs	One Leg Stand	Catch a Ball Throw a Ball Push Pull	Kick Run Jump Hop

The survey for the types of assessment to be used for 4 year old children was conducted and responses from the participants were analysed. The assessment methods which had an above 80% response rate were selected. Picture and word puzzle, and computer games were appropriate for the assessment of word recognition (see Figure 4.8). Oral tests and computer games were suggested for the recognition of Body Part, Colour, Shape, and Number, as depicted in Figure 4.9, 4.10, 4.11, and 4.12 respectively. Figure 4.13 shows the results for assessment of counting skill and Figure 4.14 displays the responses for the assessment of psychomotor skills. All the options (physical test, children games, and computer games) were rated above 80% and thus, were used for evaluation purposes. Table 4.3 summarises all the recommendations for each of the assessments.

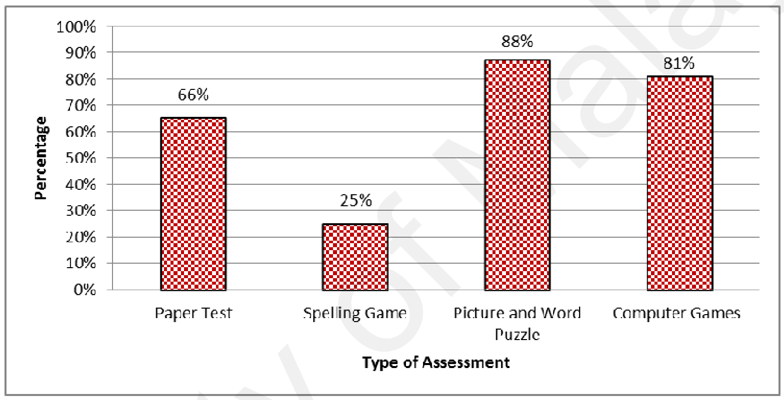


Figure 4.8: Response for the assessment of word recognition

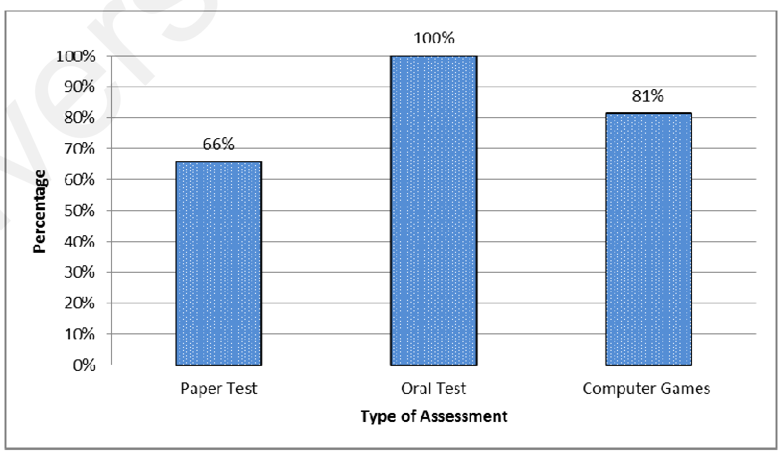


Figure 4.9: Response for the assessment of Body Part recognition

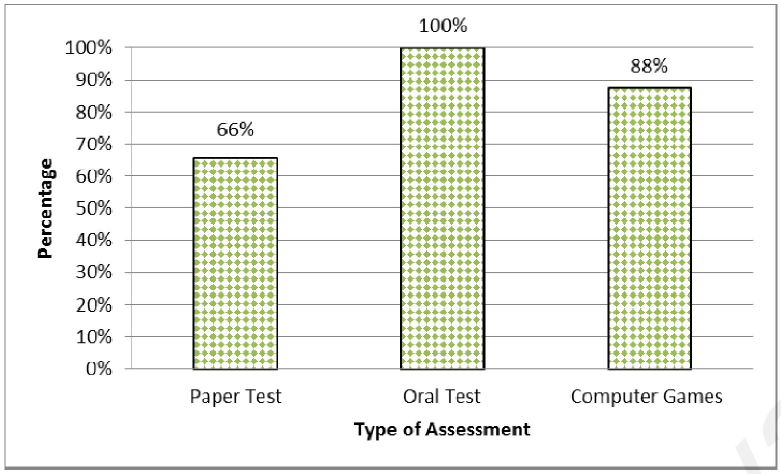


Figure 4.10: Response for the assessment of Colour recognition

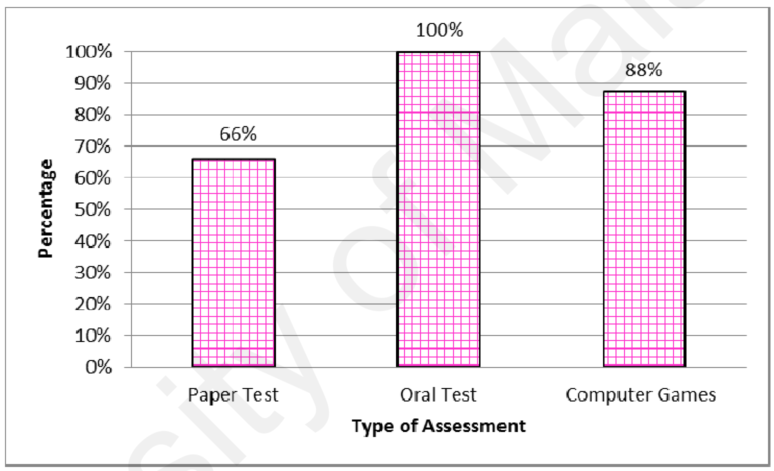


Figure 4.11: Response for the assessment of Shape recognition

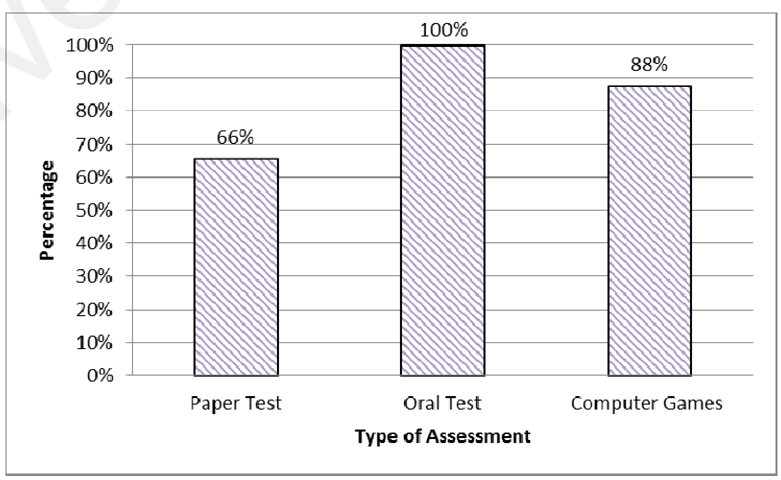


Figure 4.12: Response for the assessment of Number recognition

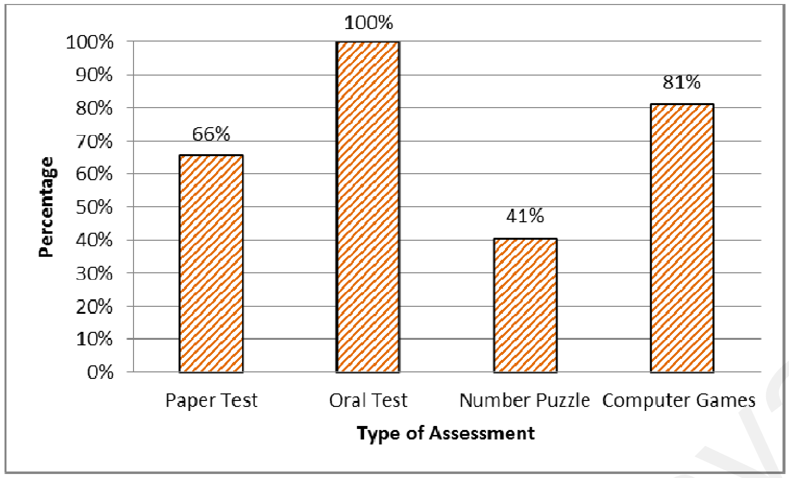


Figure 4.13: Response for the assessment of counting

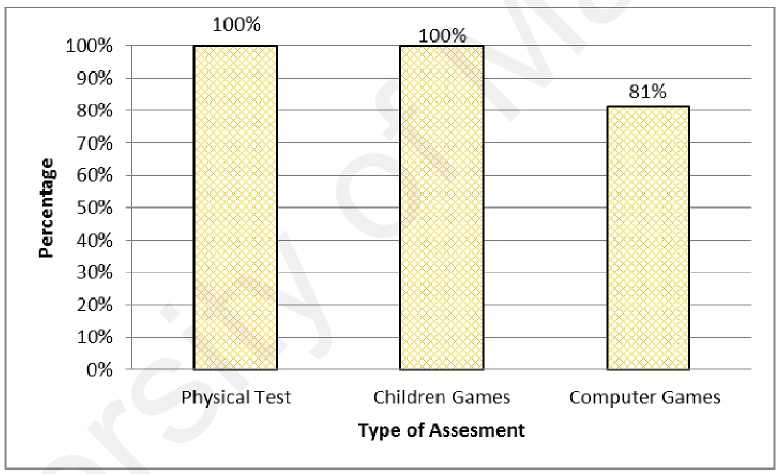


Figure 4.14: Response for the assessment of psychomotor skills

Table 4.3: Recommendation for Type of Assessment used for Age 4 Children

<table>
<tr><td>Word Recognition</td><td colspan="2">Picture and Word Puzzle</td><td rowspan="7">Computer Games</td></tr>
<tr><td>Body Part Recognition</td><td colspan="2" rowspan="4">Oral Test</td></tr>
<tr><td>Colour Recognition</td></tr>
<tr><td>Shape Recognition</td></tr>
<tr><td>Number Recognition</td></tr>
<tr><td>Counting</td><td colspan="2">Object counting</td></tr>
<tr><td>Psychomotor Skills</td><td>Physical Test</td><td>Children Games</td></tr>
</table>

4.2.2 Result for the Survey of System Prototype

There were a total of 32 participants in the second survey. Overall, more than 80% of the participants agreed that the content of the learning modules was a best fit for age 4 children. According to their feedback, *Move Your Body* was the most suitable (90.6%) followed by *Learn with Fun* (87.5%), then *Mind Games* (81.3%) (see Figure 4.15).

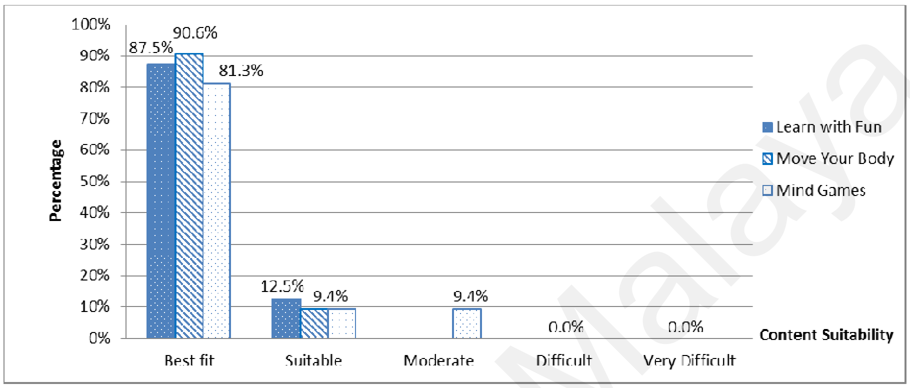


Figure 4.15: Response for content suitability of the learning modules

Figure 4.16 shows the response of content organisation in the learning modules. 90.6% of the participants agreed that the *Learn with Fun* and *Move Your Body* were well organised whereas *Mind Games* achieved 84.4%. In general, the content of all the three modules were rated over 80% as well organised.

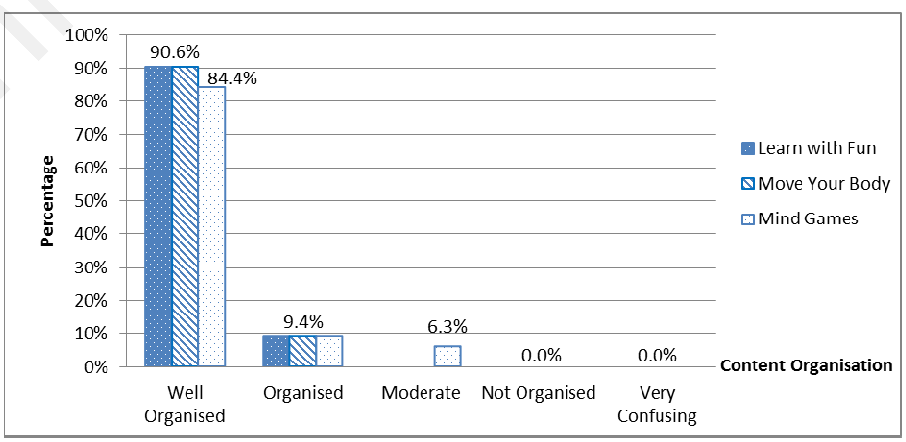


Figure 4.16: Response for content organisation of the learning modules

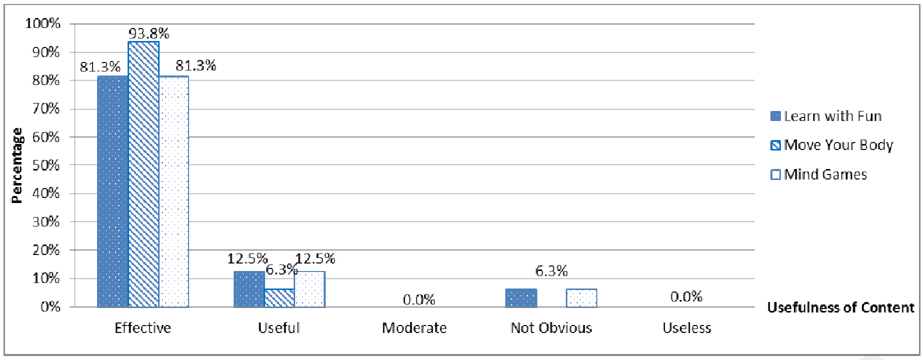


Figure 4.17: Response for the usefulness of the learning modules

Figure 4.17 shows responses for the usefulness of the learning modules. All three learning modules were rated over 80%, with *Move Your Body* at 90.6% and *Learn with Fun* and *Mind Games* both at 81.3%. However, 6.3% thought that the usefulness of *Learn with Fun* and *Mind Games* was not obvious. The reason given by those participants was they did not have the confidence to adopt the GBL approach and use the prototype as a learning tool for 4 year old children.

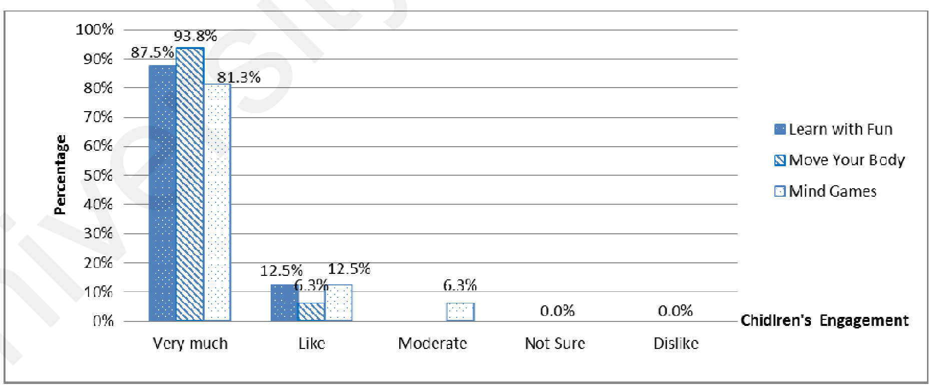


Figure 4.18: Response for teacher's opinion on children engagement

Figure 4.18 shows responses for teacher's opinion on children engagement. Overall, more than 80% of the participants came to an agreement that the children would like the learning modules very much. Again, *Move Your Body* was the most preferable module. It received the highest response at 93.8% followed by *Learn with Fun* (87.5%), then

Mind Games (81.3%). The participants explained that most young children like to learn and play computer games when given the choice.

Figure 4.19 shows the responses for the suitability of the module in *Virtual Game Assessment*. Overall, more than 80% of the participants agreed the *Virtual Game Assessment* was best fit for the evaluation of preschool children. Figure 4.20 shows the responses for the organisation of the module in *Virtual Game Assessment*, which included the categories of assessment, grouping of topics, and also the scope of each individual assessment. *Body Journey*, *Colour World*, *House of Shape*, and *Number Hut* were rated as well-organised by 93.8%, followed by *Treasure Hunt* at 81.3%.

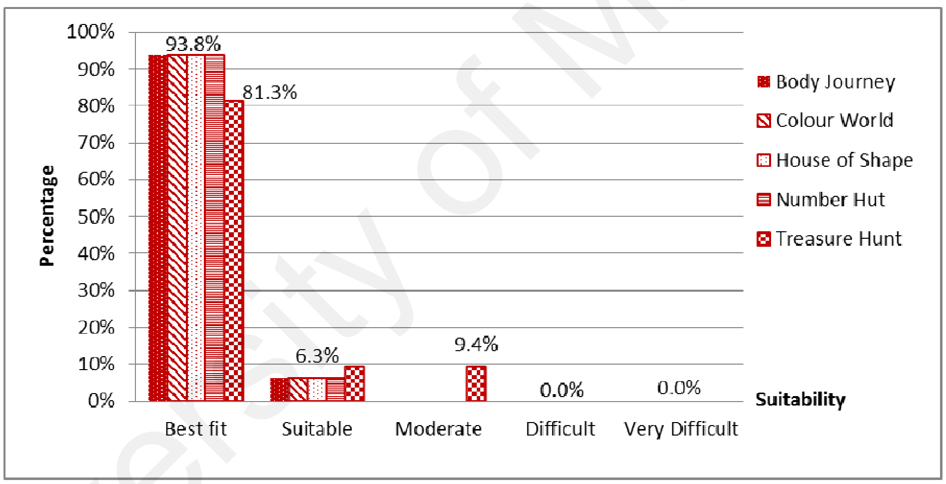


Figure 4.19: Response for the suitability of *Virtual Game Assessment* modules

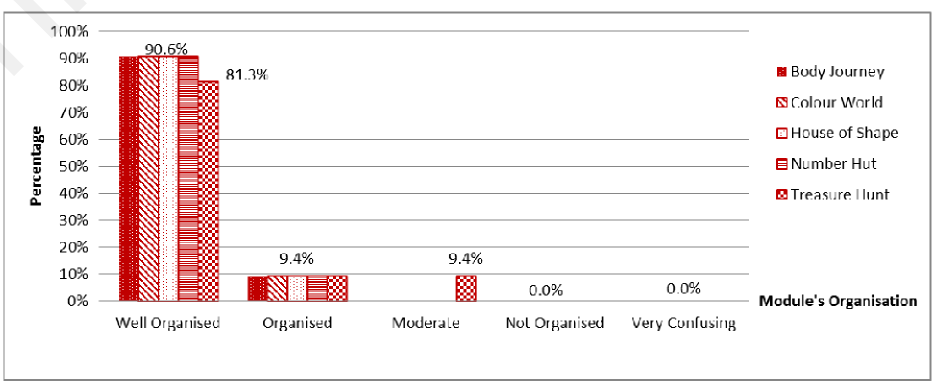


Figure 4.20: Response for module organisation of *Virtual Game Assessment* modules

Figure 4.21 shows the responses for usefulness of *Virtual Game Assessment* modules whereas Figure 4.22 summarises teachers' opinion for children engagement with *Virtual Game Assessment* modules. Overall, more than 80% of the participants agreed the *Virtual Game Assessment* was effective in evaluating preschool children's performance. However, 6.3% had doubt on the usefulness of *Virtual Game Assessment* modules in evaluating 4 year old children. Although some of the participants hesitated to adopt the GBL approach for children’s learning and assessment, most of them agreed that children would like the *Virtual Game Assessment* modules very much.

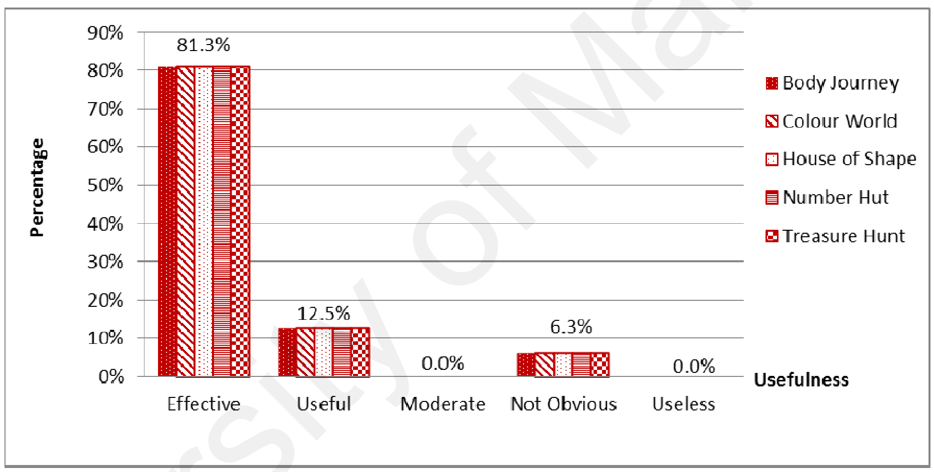


Figure 4.21: Response for the usefulness of *Virtual Game Assessment* modules

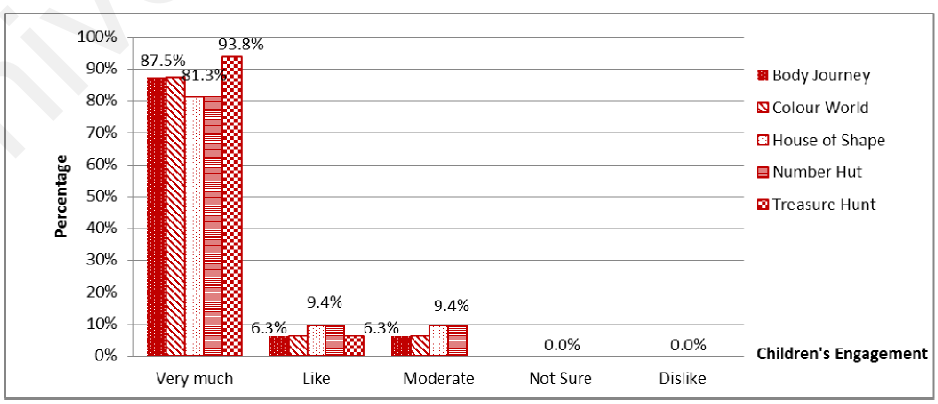


Figure 4.22: Response for teacher’s opinion on children engagement

Figure 4.23 shows the responses for suitability of the *Physical Game Assessment* modules to be used as an assessment method for 4 year old children. The response was tremendous because 5 out of total 7 assessments completely agreed (100%) that this was best fit for the evaluation of children at age 4. The same response was repeated for the organisation of assessment module (see Figure 4.24).

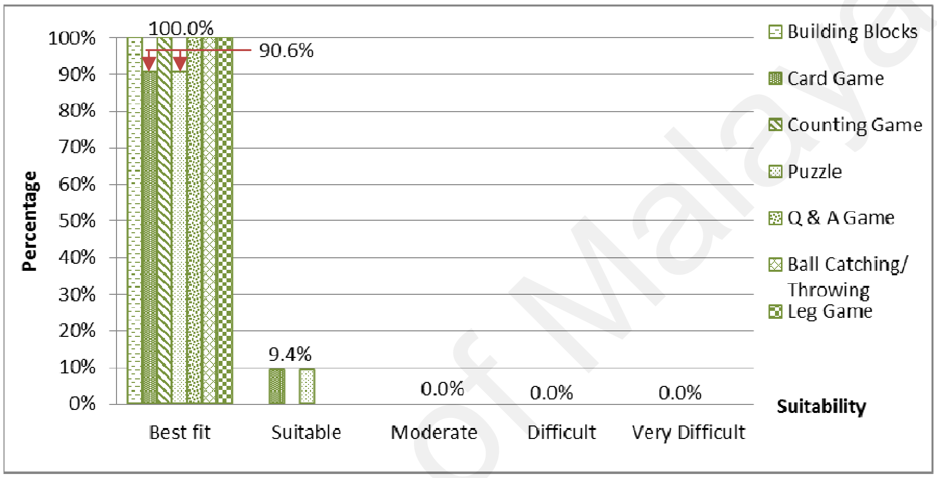


Figure 4.23: Response for the suitability of *Physical Game Assessment* modules

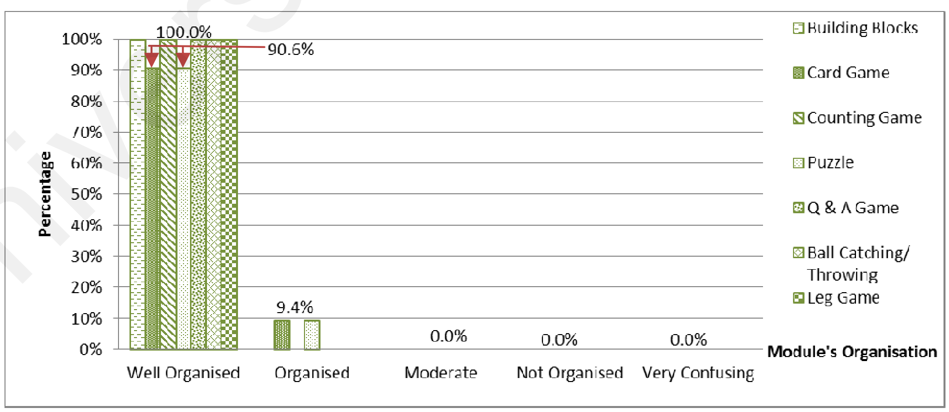


Figure 4.24: Response for module's organisation of *Physical Game Assessment* modules

Figure 4.25 and 4.26 show the responses for usefulness in the *Physical Game Assessment* modules and teacher's opinion on children's engagement with the module, respectively. All the participants agreed and accepted it as an effective method of assessment for 4 years old children. Furthermore, more than 90% of the participants had the same opinion that children would like this assessment module very much.

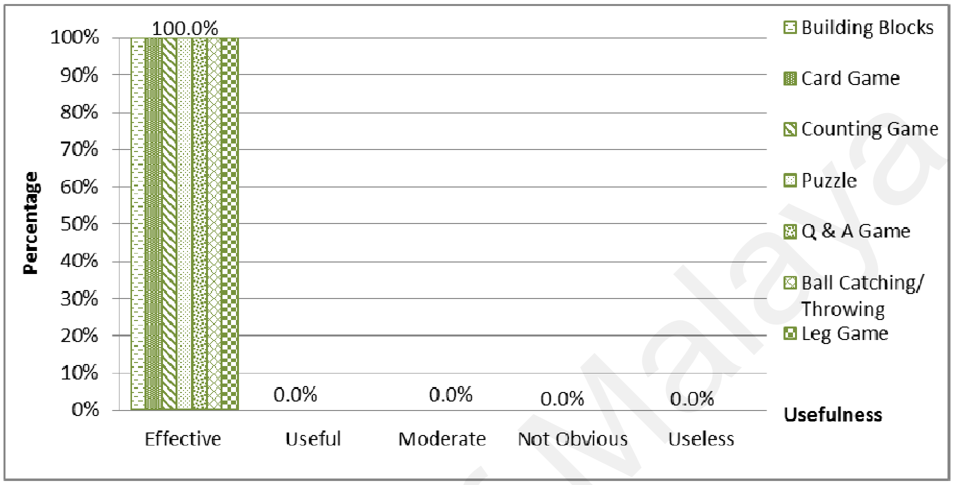


Figure 4.25: Response for the usefulness of *Physical Game Assessment* modules

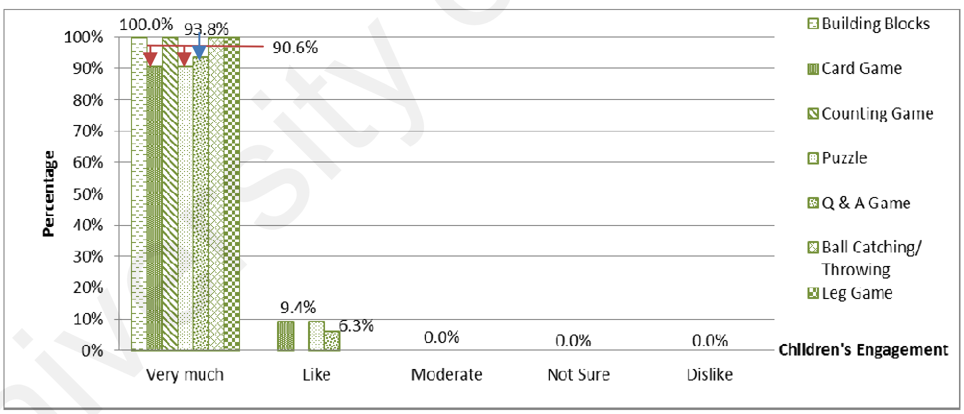


Figure 4.26: Response for teacher's opinion on children engagement

Overall, the acceptance rate of the use of *Physical Game Assessment* as an assessment method was better than that for *Virtual Game Assessment*. A further discussion was held with each of the participants privately regarding their responses. The reason for the higher rate of acceptance for *Physical Game Assessment* was they were more familiar and comfortable with this assessment. As a result, they did not require any additional training to execute the *Physical Game Assessment*. After further clarification with those participants, they agreed to use the *Virtual Game Assessment* if training was provided and all required equipment and utensils were prepared. In addition, some participants commented on the design of the prototype in relation to font size, distance between the object and respective word, as well as the objects used in the learning modules. The prototypes were revised according to the comments given.

4.3 System Architecture and Design

The proposed system, namely *myKinderLand*, is designed to facilitate preschool learning in the domains of language and communication, cognitive, and psychomotor development using GBL. *myKinderLand* is comprised of learning and assessment modules. It is a standalone system that runs on the Xbox Kinect console. The proposed system is developed using .NET C# running on Visual Studio 2012.

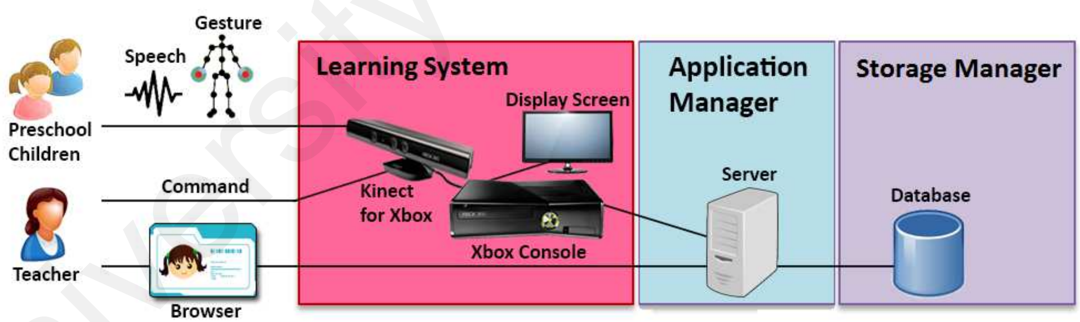


Figure 4.27: System architecture of myKinderLand

Figure 4.27 depicts the system architecture of *myKinderLand*. The system architecture consists of three main components: Learning System, Application Manager, and Storage Manager. The Learning System comprises a display screen connected to the Xbox console, which handles the display as well as the voice and gesture detection. A dialog system is designed to handle the multimedia display while an interaction system is used to detect the gesture and speech. The Application Manager provides the appropriate module to the Xbox console and manages the communication between the Learning System and Storage Manager. The Storage Manager is used to handle the data query, accessing and storing. The teacher can launch the *myKinderLand* using command via Xbox 360. The preschool children can learn via gesture and speech. The assessment result for each child will be recorded through the storage manager and the teacher can view the results through the web browser.

4.3.1 Dialog System

A dialog system is created for the Learning System to handle the multimedia display of *myKinderLand*. Figure 4.28 illustrates the flow of the dialog system. The dialog system consists of two processes which are visual dialog and audio dialog. The visual dialog manages the real time 3D (three-dimensional) interactive media rendering and animation (textual image) as well as the display of subtitle (text label) for all the conversations. The audio dialog converts the text into speech and output as audio sound. The dialog system is also responsible for the synchronisation of video dialog and audio dialog.

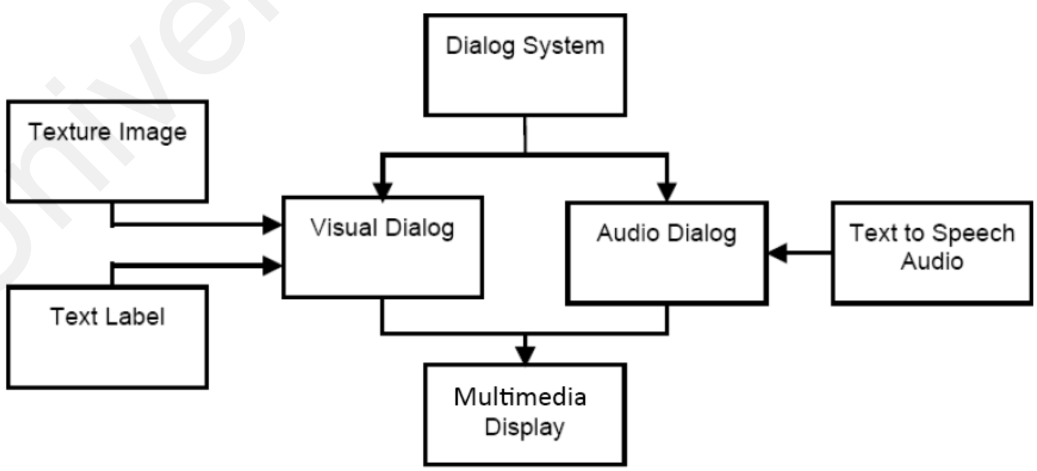


Figure 4.28: The flow of dialog system

4.3.2 Interaction System

When the Xbox 360 is on, the built-in cameras, microphones and sensors are initialised at the same time. The interaction system is an embedded function in the Xbox 360 that is used for gesture and speech recognition. In *myKinderLand*, the preschool children use speech and gesture to interact with the system for learning purposes; the teacher controls and monitors the learning by giving commands to the Learning System.

4.3.2.1 Speech Recognition Process

The flow chart of the speech recognition process is shown in Figure 4.29. The process starts by initialising the interaction system, which switches on the built-in microphone. The system will detect voice input using Microsoft Speech API. The detected speech (voice input) is then analysed using the Deep Neural Network (DNN) algorithm, an algorithm for speech recognition. DNN is selected because it has better performance in recognising human speech in the aspect of noisy speech and vocal tract differences between speakers as compared to other algorithms (Deng et al., 2013a). The speech recognition function uses confidence level (CL) to compare a speech given by different speakers or speaking styles. CL is not the indicator for speech accuracy but it helps to set the minimum acceptance level of speech recognition. A preliminary test on CL for the proposed system was executed and the best value of CL was set (CL=0.55). The detail of the test is available in Section 5.1.1.1). Assuming the detected speech has met the system requirement (CL=0.55), the system will proceed to the next exercise. Otherwise, the system will continue the process of detecting speech. If the child is unwilling to continue the exercise, the teacher uses the “Esc” key to skip or terminate the exercise.

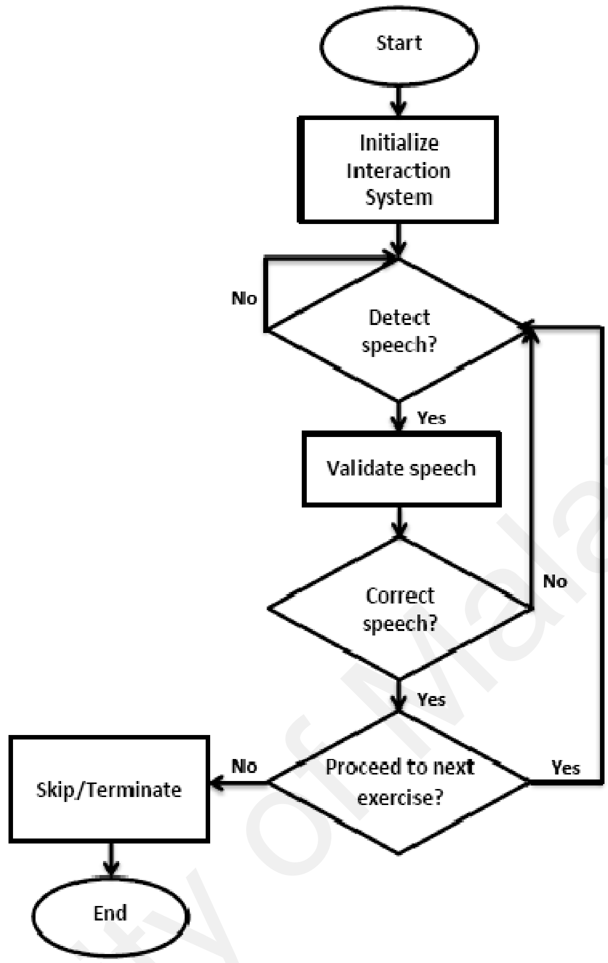


Figure 4.29: Flow chart of speech recognition process

4.3.2.2 Gesture Recognition Process

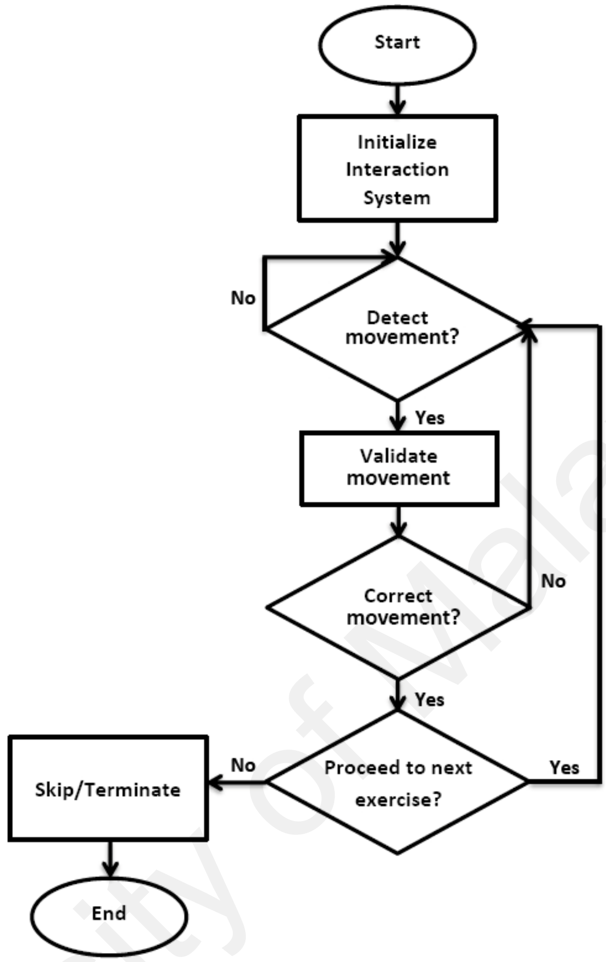


Figure 4.30: Flow chart of gesture recognition process

The flow chart of the gesture recognition process is shown in Figure 4.30. The proposed system uses the Microsoft Kinect sensor to detect the preschool children's gesture (movement). The Microsoft Kinect sensor has a RGB (red, green, and blue) camera that stores three channel data in a 1280x960 resolution. This feature makes capturing a colour image possible. Moreover, the Microsoft Kinect sensor has an infrared (IR) emitter and an IR depth sensor. The emitter emits infrared light beams and the depth sensor reads the IR beams reflected back to the sensor. The reflected beams are converted into depth information through measuring the distance between an object (preschool children) and the sensor. This method enables the proposed system to capture the depth information of an object. After obtaining the depth image information, a Skeletal tracking algorithm is used to analyse the captured information. Skeletal tracking is a three-dimensional (3D) gesture recognition algorithm. It was adopted because it has better performance in recognising human gestures in real time as compared to other algorithms (Zhang, 2012).

The process starts by initialising the interaction system. After initialisation, the interaction system will start to detect the visual signal (movement). If the detected movement match the system requirement, the system will proceed to the next exercise. Otherwise, the system will continue the process of detecting a movement. The teacher uses the “Esc” key to skip or terminate an exercise.

4.4 Learning Modules

Learning Modules are used to convey the cognitive and psychomotor materials to the preschool children. There are three Learning Modules in the proposed system, which are *Learn with Fun*, *Move Your Body*, and *Mind Games*. *Learn with Fun* promotes the development of language and communication skills, *Move Your Body* develops the psychomotor skills, and *Mind Games* facilitates the transfer of cognitive and psychomotor skill to the preschool children. Figure 4.31 shows the hierarchical chart of Learning Module, which is used for system navigation. The categories, words, psychomotor skills, and exercises used for the aforementioned modules are identified based on the selected Early Childhood Care and Education (ECCE) syllabus and the survey result obtained from 16 preschools located in the Klang Valley, Malaysia. Teachers are trained to use the proposed system to deliver the teaching materials to the preschool children.

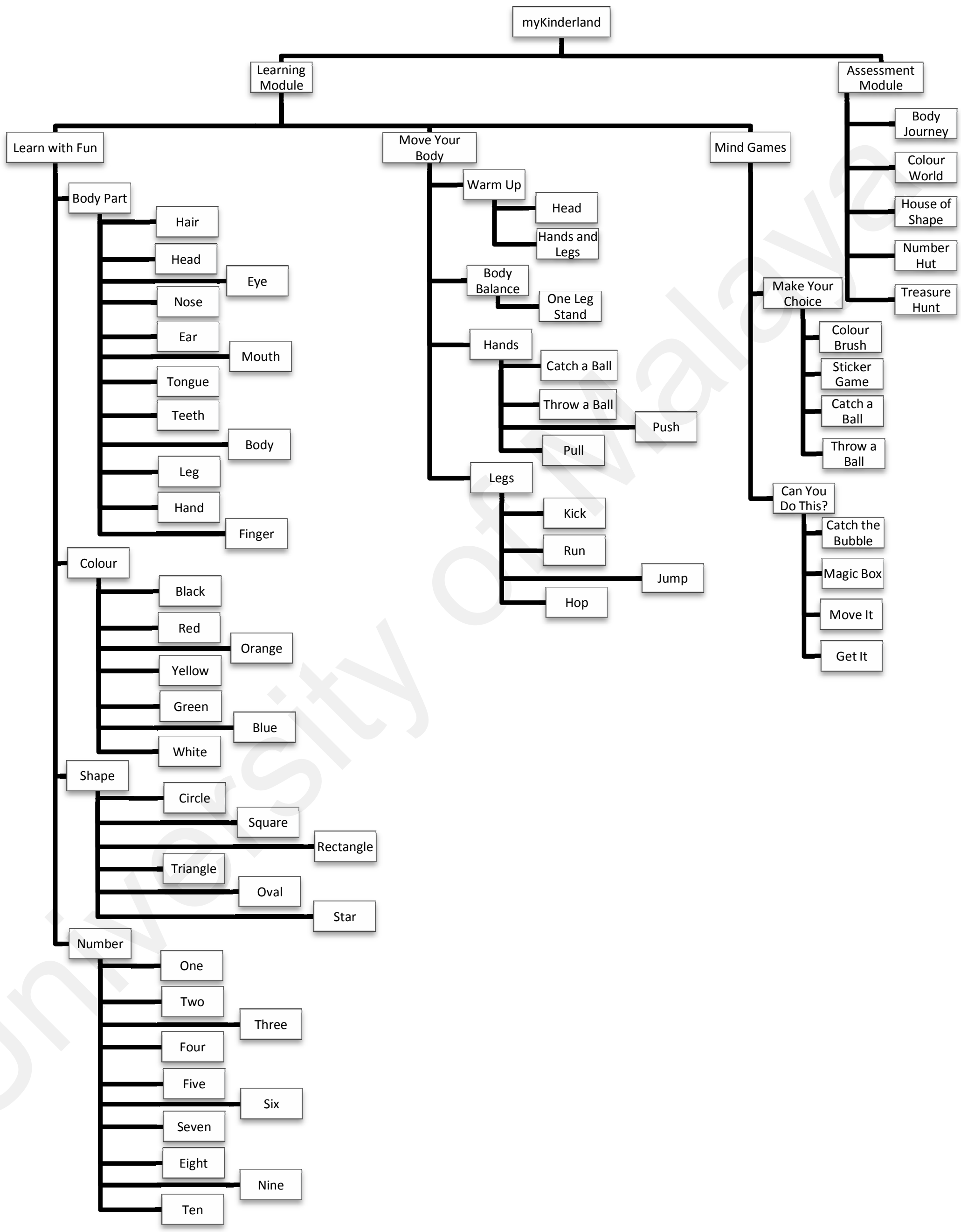


Figure 4.31: Hierarchical chart for learning module


```
Program start;

Load Welcome screen;

Play welcome.wav;
```

(a) Welcome screen (b) pseudocode for welcome screen

Figure 4.32: Welcome screen and its pseudocode


```
Load main menu;

If learning button is on hold or
sound of one is received;
Load learning module;

If assessment button is on holdor
sound of two is received;
Load assessment module;

If esc button is pressed;
Exit program;
```

(a) Main menu (b) pseudocode for main menu

Figure 4.33: Main menu and its pseudocode

(a) Menu for learning modules (b) Menu for assessment modules

Figure 4.34: Menus for learning and assessment modules

When the system is launched, Dr John, an avatar, who acts as a medical officer is shown and gives his greeting (see Figure 4.32). After that, a menu screen with two options namely Learning and Assessment will appear (see Figure 4.33). The *Learning* option will direct to a menu screen with three learning modules: *Learn with Fun, Move Your Body,* and *Mind Games* (see Figure 4.34 (a)) while the *Assessment* option will direct to a menu screen with five assessment modules, which are *Body Journey*, *Colour World*, *House of Shape*, *Number Hut*, and *Treasure Hunt* (see Figure 4.34 (b)).

The menu screen allows the teacher to select the option using the voice recognition command or motion. The teacher is required to pronounce the word *One* or move his hand to the *Learning* button if the teacher wants to choose the learning modules. To select the *Assessment*, the teacher can move his hand to the *Assessment* button or pronounce the word *Two* (see Figure 4.33(a)). The teacher can terminate the proposed module by pressing the "Esc" key. The pseudocode for the menu screen is similar in that the system will direct the teacher to the respective module if the option is selected. The teacher can go back to the main menu by moving his hand to the *Home* button.

4.4.1 Learn with Fun

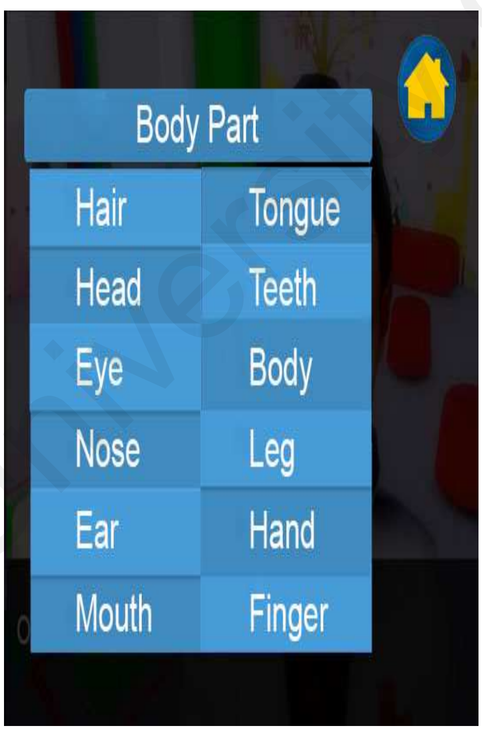
Figure 4.35 shows the *Learn with Fun* module. The module consists of four sub-modules, which are *Body Part*, *Colour*, *Shape* and *Number*. All the modules are independent and there is no prerequisite for each of the modules.

Figure 4.35: The menu of *Learn with Fun* module

Table 4.4 shows the proposed syllabus for *Learn with Fun* module. For each module, there are certain words that the preschool children are required to pronounce.

Table 4.4: Proposed syllabuses for *Learn with Fun* module

	Exercise			
No	**1. (Body part)**	**2. (Colour)**	**3. (Shape)**	**4. (Number)**
1	Hair	Black	Circle	One
2	Head	Red	Square	Two
3	Eye	Orange	Rectangle	Three
4	Nose	Yellow	Triangle	Four
5	Ear	Green	Oval	Five
6	Mouth	Blue	Star	Six
7	Tongue	White		Seven
8	Teeth			Eight
9	Body			Nine
10	Leg			Ten
11	Hand			
12	Finger			




```
Load bodyPart menu;

If hair button is on hold;
Load hair_exercise;

If head button is on hold;
Load head_exercise;

If eye button is on hold;
Load eye_exercise;

If nose button is on hold;
Load nose exercise;

If ear button is on hold;
Load ear_exercise;

If mouth button is on hold;
Load mouth_exercise;

If tongue button is on hold;
Load tongue_exercise;

If teeth button is on hold;
Load teeth_exercise;

If body button is on hold;
Load body_exercise;

If leg button is on hold;
Load leg_exercise;

If hand button is on hold;
Load hand_exercise;

If finger button is on hold;
Load finger_exercise;

If home button is on hold;
Load learn_with_fun menu;
```

(a) Screen for selection (b) Pseudocode for selection screen

Figure 4.36: The drop down menu of *Body Part* module and its pseudocode

When the *Body Part* module is selected, a drop down menu with twelve exercises: *Hair, Head, Eye, Nose, Ear, Mouth, Tongue, Teeth, Body, Leg, Hand,* and *Finger*, are shown (see Figure 4.36 (a)). The pseudocode for the *Body Part* menu is depicted in Figure 4.36 (b). The teacher can select any word for the children to practice. If the *Hair* exercise is selected, Dr. John and another lady avatar, Miss Daisy, will show up. A small screen (visual aid) that focuses on Miss Daisy's hair together with the related text will appear as shown in Figure 4.37. Dr. John will explain to the children by saying "This is hair." and "The hair is soft.". After that, Dr. John will say "Let's pronounce the word *Hair* together.". The proposed system will wait for a voice input from the children. The teacher needs to guide the children to respond to the word *Hair*. Dr. John will repeat the instruction every three seconds when the proposed system does not receive a response or the response does not match the system requirement. The proposed system uses the detection method described in section 4.3.2.1 to detect the voice input. Once the proposed system has received a correct response, Dr. John will respond "Well done." (see Figure 4.38). The pronunciation of the word *Hair* is considered completed. Figure 4.39 shows the pseudocode for the *Hair* exercise. After that, the drop down menu for the *Body Part* module will appear automatically (see Figure 4.36(a)). The teacher can request the children to repeat the pronunciation of a word if the former thinks that the latter need more practice. In addition, he can proceed to other *Body Part* exercises such as *Head, Eye, Nose, Ear, Mouth, Tongue, Teeth, Body, Leg, Hand,* and *Finger* (see Figure 4.40). For cases where the children are reluctant to pronounce certain words due to concentration and emotional issues, the teacher can terminate the proposed system by pressing the "Esc" key.

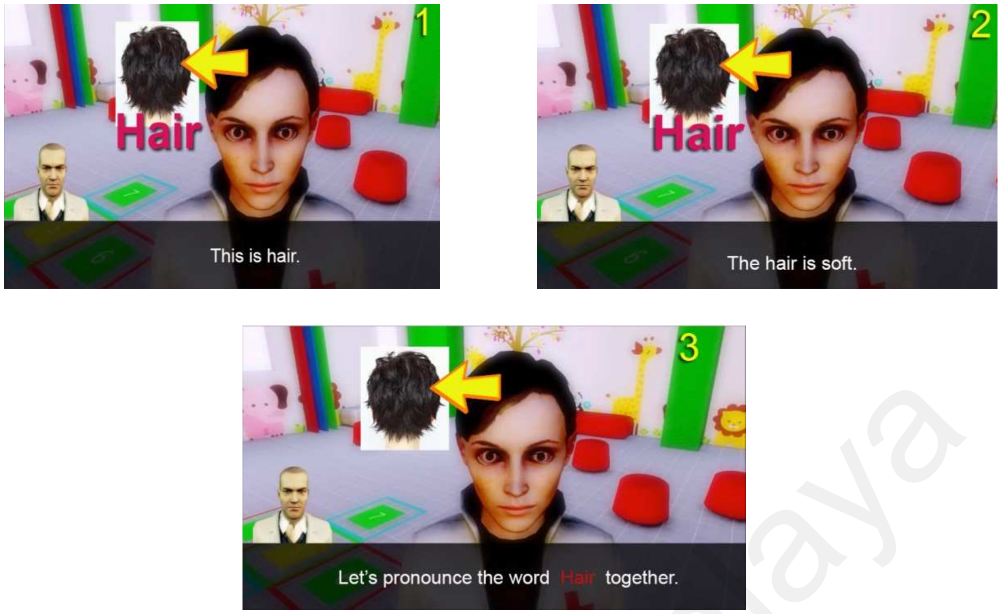


Figure 4.37: Pronounce the word *Hair*

Figure 4.38: A response given by the avatar after receiving a correct input for the *Hair* exercise

```
Start hair_exercise;
Load hair_screen1;
Play hair_sound1.wav;
Load hair_screen2;
Play hair_sound2.wav;
Load hair_screen3;
Play hair_sound3.wav;

While received_sound is not hair or idle more than 3 seconds;
        {
                Load hair_screen3;
                Play hair_sound3.wav;
        }

Load hair_screen4;
Play hair_sound4.wav;

Load bodyPart menu;
```

Figure 4.39: Pseudocode for *Hair* exercise

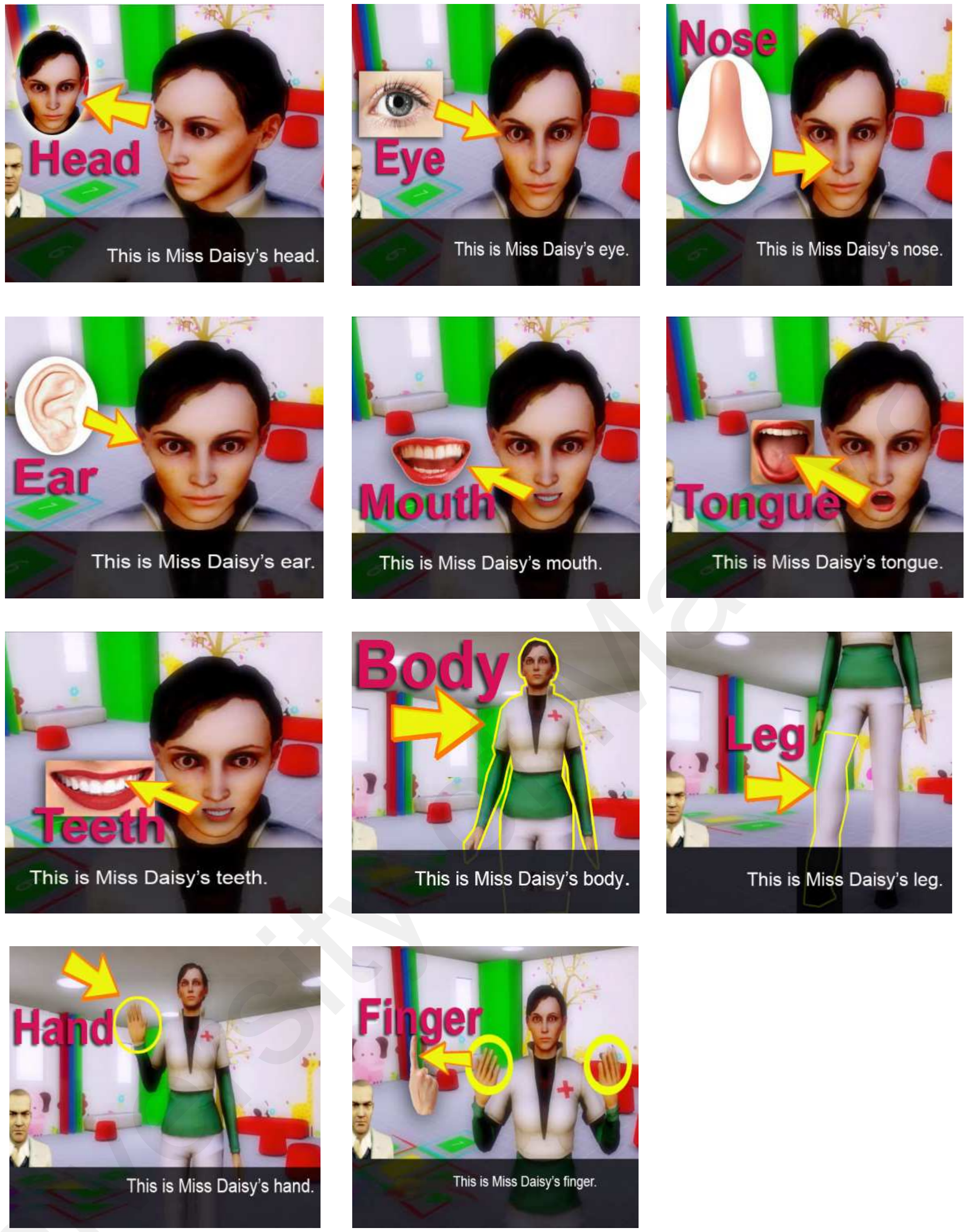


Figure 4.40: ***Head, Eye, Nose, Ear, Mouth, Tongue, Teeth, Body, Leg, Hand,*** **and** ***Finger*** **exercises in** ***Body Part*** **module**

The *Colour*, *Shape*, and *Number* modules provide the exercises to the preschool children in a similar way. The drop down menu for *Colour*, *Shape*, and *Number* modules (see Figure F1) and the corresponding exercises for each module (see Figure F2, F3, &F4) were attached in Appendix F. Likewise, the teacher needs to guide the children to respond to the selected word in the respective module. The same response and detection method of *Body Part* module will be used.

4.4.2 Move Your Body

Figure 4.41 shows the *Move Your Body* module. The module consists of four sub-modules, which are *Warm Up, Body Balance, Hands,* and *Legs*. All the modules are independent and there is no prerequisite for each of the module.

Figure 4.41: The menu of *Move Your Body*

Table 4.5 shows the proposed syllabus for the *Move Your Body* module. There are four sub-modules, which are *Warm Up, Body Balance, Hands,* and *Legs*. For each module, there are certain motor skills that the children are required to perform. Although there is no prerequisite for any of the exercises, teachers are advised to perform the *Warm Up* exercise first before conducting other exercises to minimise muscle and joint injuries (Allen, Hannon, Burns, & Williams, 2014; Woods, Bishop, & Jones, 2007).

Table 4.5: Proposed syllabuses for the *Move Your Body* Module

	Exercise			
No	**1. (Warm Up)**	**2. (Body Balance)**	**3. (Hands)**	**4. (Legs)**
1	Head	One Leg Stand	Catch a Ball	Kick
2	Hands and Legs		Throw a Ball	Run
3			Push	Jump
4			Pull	Hop

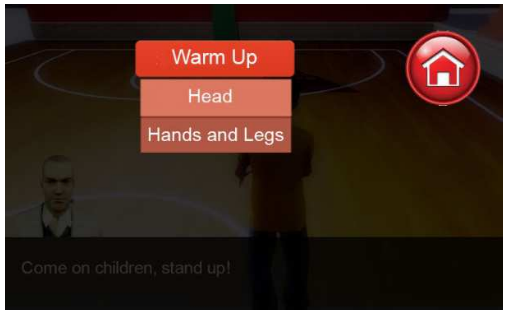
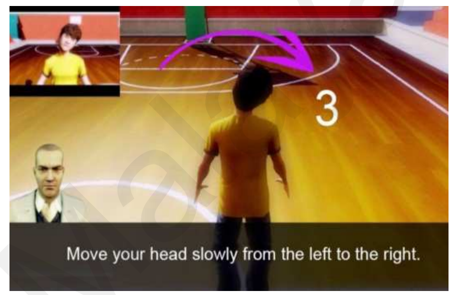


Figure 4.42: The drop down menu of *Warm Up* module

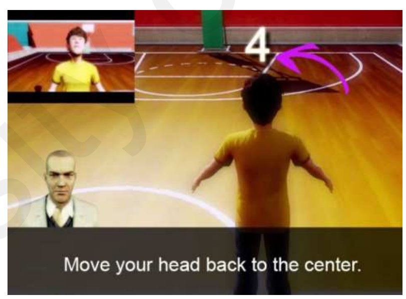
When the teacher selects the *Warm Up* module, a drop down menu that consists of *Head* and *Hands and Legs* is shown (see Figure 4.42). If the *Head* option is selected, Dr. John and two avatars dressed like preschool kids will show up. Dr. John will speak out the direction of the head movement and Jack (the avatar that is placed at the top left corner of the screen) will demonstrate the movement to the children. Jack's movement is shown as a mirror reflection to the children. Research has found that using mirror image (demonstration/scaffolding) in teaching can promote learning especially mimicking physical exercises or movements (Anderson, Grossman, Matejka, & Fitzmaurice, 2013; Kim, Stephenson, Morris, & Jackson, 2014; Reissig, Puri, Garry, Summers, & Hinder, 2015). James, another avatar with his back view only ever shown, is used to imitate the movement of the preschool child when he moves his head (see Figure 4.43). Children can self-examine whether their heads are moving in the correct direction by looking at the avatar. This scaffolding feature is implemented in the proposed system because research has found that imitation is an effective method to facilitate, assist and improve the learning of a motor skill (Hayes, Hodges, Scott, Horn, & Williams, 2007; Labiadh, Ramanantsoa, & Golomer, 2012). The kid avatars are designed based on the concept of peer learning (learning from their peers) to engage students' interest and improve their learning (Ryokai, Vaucelle, & Cassell, 2003).

Figure 4.43: Dr. John, Jack and James, the back view avatar

(a) Imitate the head movement of the children from the right to the left



(b) Imitate the head movement of the children from the left to the right



(c) Imitate the head movement of the children to the center position

Figure 4.44: Dr. John and the two avatars in *Head* exercise

There are three movements that the children are required to perform for the *Head* exercise. Initially, the children are required to move their head from right to left (step 1 and 2), after that, from left to right (step 3), and lastly they have to move their head back to the centre position (step 4) (see Figure 4.44). As mentioned earlier, Dr. John will vocalise the direction of the head movement. After that, Jack will move his head from right to left. Then, the proposed system will wait for a gesture input from the children. The teacher needs to guide the children to respond to the proposed system by moving their head to the correct direction. Dr. John will repeat the instruction every three seconds and Jack will respond accordingly to the instruction when the proposed system does not receive a response or the response does not match the system requirement.

The proposed system will use the Microsoft Kinect sensor to detect the children's gesture as mentioned in section 4.3.2.2. Once the proposed system has received a correct response, Dr. John will respond "Well done" (see Figure 4.45). Figure 4.46 shows the pseudocode for the *Head* exercise.

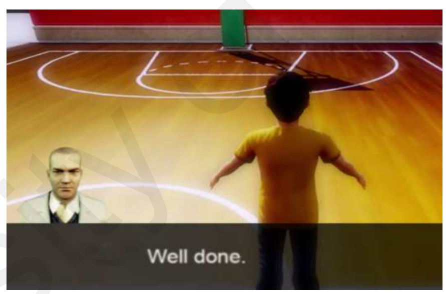


Figure 4.45: Compliment screen for *Head* exercise

```
Start head_exercise;
Load head__screen1;
Play head_sound1.wav;

While received_movement is not valid or idle more than 3 seconds;
       {
              Load head__screen1;
              Play head_sound1.wav;
              Load head__centerAvatar with received_movement;
       }

Load head__screen2;
Play head_sound2.wav;
Load Warm up menu;
```

Figure 4.46: Pseudocode for *Head* exercise

Figure 4.47: *Hands and Legs* exercise

Similarly, the teacher can request the children to repeat the exercise if he thinks that the children need more practices. The teacher may proceed to the *Hands and Legs* exercise (see Figure 4.47) by navigating his hand to the particular motor skill in the drop down menu.

The *Body Balance, Hands,* and *Legs* modules work in a similar way. The drop down menu for each of the aforementioned module (see Figure F) and the respective exercises and pseudocode (see Figure F7, F8, & F9) were attached in Appendix F. A response and detection method similar to *Warm Up* module will be used.

4.4.3 Mind Games

Figure 4.48 shows the *Mind Games* module. The module consists of two sub-modules, which are *Make Your Choice* and *Can You Do This?*. *Make Your Choice* and *Can You Do This?* are designed to foster the cognitive and psychomotor development of the children. The exercises and content are designed based on the syllabus in the *Learn with*

Fun and *Move Your Body* modules. The teacher needs to ensure that children have completed both *Learn with Fun* and *Move Your Body* modules before they can enrol in the *Mind Games* module.

Figure 4.48: The menu of *Mind Games* module

Figure 4.49: The drop down menu of *Make Your Choice* module

When the teacher select the *Make Your Choice* module, a drop down menu with four exercises – *Colour Brush, Sticker Game, Catch a Ball,* and *Throw a Ball* are shown (see Figure 4.49). The teacher can select any exercise for the children to practice. These exercises are designed to train the children in decision-making and psychomotor skill development. Generally, decision-making refers to the ability to make a right or smart choice (Andrews & Moussaumai, 2015). Decisions can be goal-oriented or without a specific goal (Jacobs & Klaczynski, 2006). For a goal-oriented decision, a decision must achieve the desired mission. On the other hand, a decision that is without a specific goal does not result in any explicit consequences. Making a correct decision is important. A correct decision-making may bring success to a person (Yu, 2013).

However, making a wrong decision can lead a person to encounter a problem or failure (Hartel, 2013). Thus, the development of decision-making is crucial and should be started in the early childhood via the appropriate context (Byrnes, 2013; Kidd, Palmeri, & Aslin, 2013). *Colour Brush* exercise practices the type of decision without a specific goal. On the other hand, *Sticker Game, Throw a Ball* and *Catch a Ball* exercises offer the children an opportunity to make two types of decisions, which are goal-oriented and without specific goal decisions. Due to the similarity of the exercises in functionality as well as in the response and detection method, this section will only explain *Colour Brush* and *Catch a Ball* exercises; the other exercises (*Sticker Game* and *Throw a Ball*) and corresponding pseudocode are attached in Appendix F (see Figure F10, F11, F12, F13, & F14).

(a) Menu for the *Colour Brush* exercise

(b) The selected object and the colour palette

(c) Compliment screen for complete painting

Figure 4.50: *Colour Brush* exercise

When the teacher selects the *Colour Brush* exercise, Dr. John and a menu of six objects – *House, Truck, Flower, Robot, Cake, and Dragonfly*, are shown (see Figure 4.50(a)).

All these objects are formed using two-dimensional (2D) shapes such as circle, square, rectangle, triangle, oval, and star, all of which are covered in the *Learn with Fun* module. Dr. John will then ask the children to choose an object from the menu for painting purpose. The proposed system uses the Microsoft Kinect sensor to detect the children's gesture. The teacher needs to guide the children to choose only one option in the proposed system. The same response and detection method as that for the *Warm Up* module will be used.

If the *House* object is selected, a house object together with a colour palette that consists of orange, black, white, red, blue, green, and yellow colours are displayed (see Figure 4.50(b)). The children can choose any colour to paint the object. To do the painting, the children are required to drag any colour they prefer and release it to the selected object. The proposed system waits for a gesture input from the children. The teacher needs to guide the children to colour the object. To complete the painting exercise, the children have to press the green button with a tick signage, which is located at the top left corner of the screen (see Figure 4.50(b)). Once the green button is pressed, the painting exercise for the *House* object under the *Colour Brush* exercise is considered completed and Dr. John will respond "Well done! You have completed a painting." (see Figure 4.50(c)). The menu for the *Colour Brush* exercise will appear automatically and the children can select another object for painting (see Figure 4.50(a)). Figure 4.51 shows the pseudocode for the *Colour Brush* exercise. Other objects for colouring are depicted in Figure 4.52.

```
Start colourBrush_exercise;
Load wheelOfChoice_screen;
Play wheelOfChoice_sound.wav;

While no object is selected or idle more than 3 seconds
        {
                Load wheelOfChoice_screen;
                Play wheelOfChoice_sound.wav;
        }

        Load colourPalette_screen;
        Play colourPalette_sound.wav;

        While no colour is selected or idle more than 3 seconds
        {
                Load colourPalette_screen;
                Play colourPalette_sound.wav;
        }

        Check colour;
        Load colourPalette_screen_with_colourApplied;

        If green_tick_button is on hold;
        {
                Load compliment_screen;
                Play compliment_sound.wav;
                Load colourBrush_exercise;
        }
```

Figure 4.51: Pseudocode for *Colour Brush* exercise

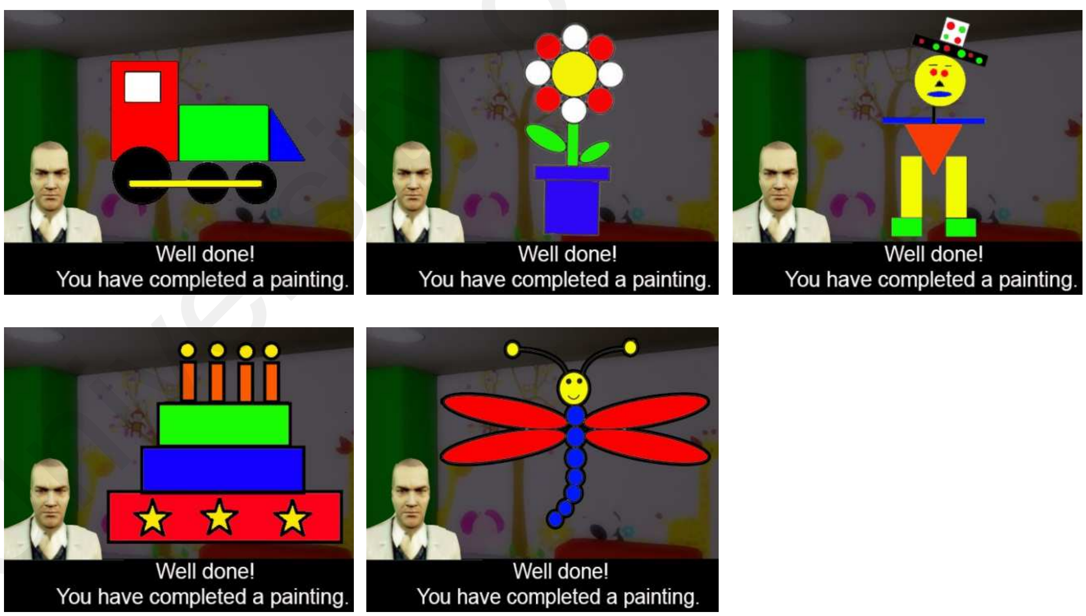
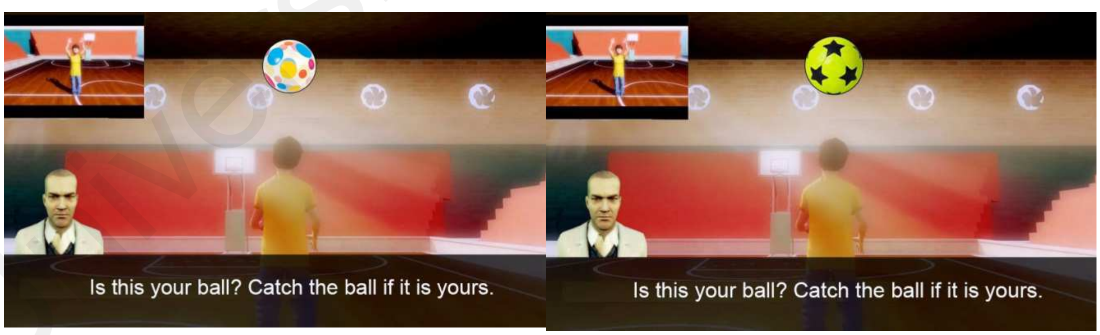


Figure 4.52: *Truck, Flower, Robot, Cake,* and *Dragonfly* exercises

When the *Catch a Ball* exercise is selected, Dr. John and two kid avatars (Jack and James) are shown. The children are given four balls and each ball has a different pattern (repetition of shape) covers on its surface. There are six patterns –namely circles, squares, rectangles, triangles, ovals, and stars. All these shapes are covered in the *Learn with Fun* module. The proposed system uses a uniform randomisation algorithm to randomly select four balls with different patterns each time when the exercise is launched. Dr. John will ask the children to choose a ball out of the four balls (see Figure 4.53 (a)). The same response and detection method as for the *Warm Up* module will be used.

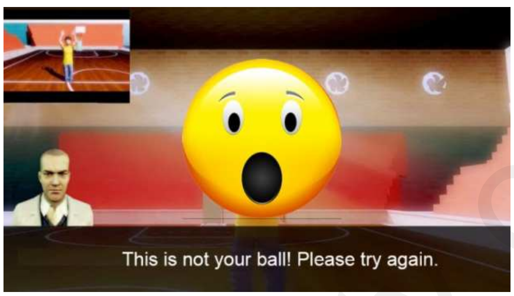
(a) Choose a ball (b) Information screen



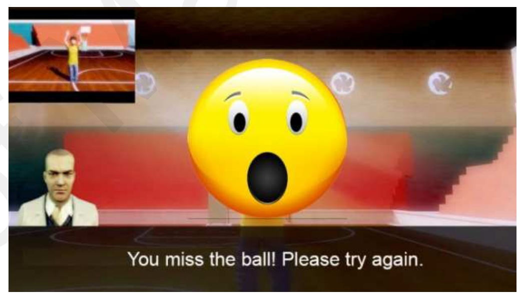
(c) Distraction test (d) The actual choice

Figure 4.53: *Catch a Ball* exercise

When the children have selected a ball with star patterns, an information screen will appear to remind them of their ball choice and the action they should have taken (see Figure 4.53 (b)). After that, a ball with other pattern will show up and Dr. John will give his instruction by saying “Is this your ball? Catch the ball if it is yours.” Catching the right ball is a goal-oriented decision. In this exercise, a distraction test that uses a ball with a different pattern will be randomly selected to test the children’s memory before the actual choice (see Figure 4.53 (d)). For example, assume a ball with an oval pattern is shown in the screen, and Dr. John asks, “Is this your ball? Catch the ball if it is yours.” (see Figure 4.53 (c)). If the children catch the ball now, Dr. John will respond “This is not your ball! Please try again.” (see Figure 4.54 (a)). If the children see the right ball but are not able to catch it, Dr. John will respond “You missed the ball! Please try again.” (see Figure 4.54 (b)).



(a) Encouragement screen for the wrong choice



(b) Encouragement screen for the miss of catch

Figure 4.54: The encouragement screen for *Catch a Ball* exercise

If the children manage to catch the correct ball, a compliment screen will be displayed and Dr. John will respond “Good catch. Well done!” (see Figure 4.55). Figure 4.56 shows the pseudocode for the *Catch a Ball* exercise.

Figure 4.55: The compliment screen for *Catch a Ball* exercise

```
Start catchBall_exercise;
Load chooseBallPattern_screen;
Play chooseBall_sound.wav;

While no ball is selected or idle more than 3 seconds
        {
                Load chooseBallPattern_screen;
                Play chooseBall_sound.wav;
        }

Check BallPattern;

        Load informationScreen;
        Play informationScreen_sound.wav;
        Load distrationBallScreen;
        Play distrationBall _sound.wav;

        If selectedBall is caught;
        {
                Load wellDone_screen;
                Play wellDone_sound.wav;
                Load make_your_choice menu;
        }
        Else
        {
                Load encouragement_screen;
                Play encouragement_sound.wav;
                Check BallPattern;

        }
```

Figure 4.56: Pseudocode for *Catch a Ball* exercise

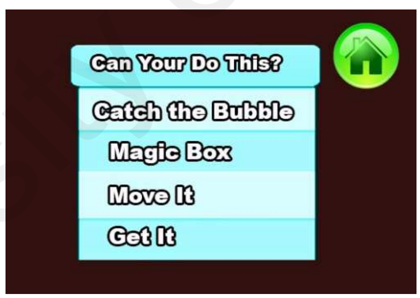


Figure 4.57: The drop down menu of *Can You Do This?* module

When the teacher selects the *Can You Do This?* module, a drop down menu with four exercises – *Catch the Bubble, Magic Box, Move It,* and *Get It*, are shown (see Figure 4.57). These exercises are designed to foster the cognitive and psychomotor development of children through problem solving exercises. Problem solving is a process of seeking an appropriate solution involving thinking skills such as reasoning, decision-making and creative thinking (Whimbey et al., 2013). The teacher can select any exercise for the children to practice. Before solving any problem, the children are required to identify and understand the problem, then required to search for a solution to address the problem. Due to the similarities in the exercises, in functionality as well as in the response and detection methods, this section will only explain *Magic Box* and *Get It* exercises. The other exercises (*Catch the Bubble* and *Move It*) and corresponding pseudocode are attached in Appendix F (see Figure F15, F16, F17, & F18).

(a) Problem solving scenario

(b) Encouragement screen

(c) New type of object selected for problem solving

(d) Compliment screen

Figure 4.58: *Magic Box* exercise

When the teacher selected the *Magic Box* exercise, a stage with a magic box is shown (see Figure 4.58 (a) scene 1). This exercise requires the children to count the number of objects that appear once the magic box is opened. There are six types of objects and the shapes of these objects are taken from the *Shape* module covered under the *Learn with Fun* module. The proposed system will randomly select both the type and the number of objects. The number of objects is taken from the *Number* module covered under the *Learn with Fun* module as well.

This example demonstrates how the exercises work. Assume that three *Star* shape objects have been selected by the proposed system randomly (see Figure 4.58 (a) scene 2). Dr. John will ask the children to count the number of the stars that appeared. There are two options given to the children. One is the correct answer and the other, a random number (see Figure 4.58 (a) scene 3).The same response and detection method as that for the *Warm Up* module is used. Dr. John will respond "Let's try again." if the children have selected the wrong answer (see Figure 4.58 (b)). The proposed system will then randomly select another type of object and the number of that object using the same selection algorithm (see Figure 4.58 (c)). The children will need to solve the problem to progress. If the children are able to count precisely and give the correct answer, Dr. John will say "Well done!" (see Figure 4.58 (d)). The *Magic Box* exercise will then be considered completed. Figure 4.59 shows the objects used for the *Magic Box* exercise. Once the problem is solved, the drop down menu for *Can You Do This?* will appear automatically (see Figure 4.57). Figure 4.60 shows the pseudocode for the *Magic Box* exercise.

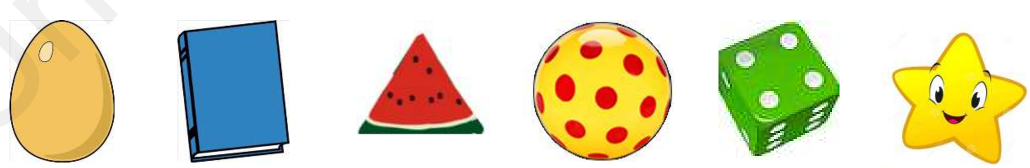
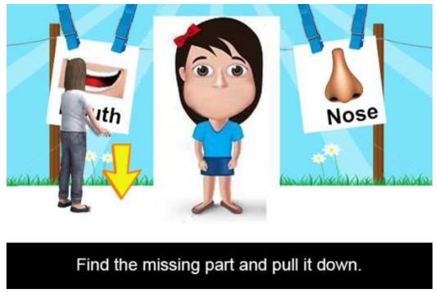


Figure 4.59: Six objects that used for counting in *Magic Box* exercise

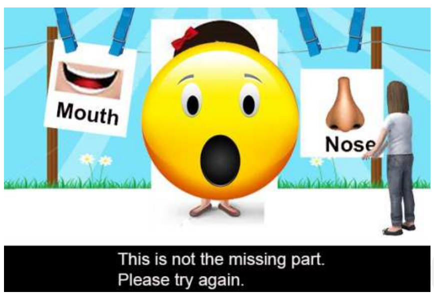
```
Start magicBox_exercise;
Load magicBox_screen;
Play magicBox_sound.wav;

Select quantity;
Select object;
Load instruction_screen;
Play instruction_sound.wav;
Load choices_screen;

While no choice is selected or idle more than 3 seconds
        {
                Load instruction_screen;
                Play instruction_sound.wav;
                Load choices_screen;
        }

        If answer is correct;
        {
                Load compliment_screen;
                Play compliment_sound.wav;
                Load can_you_do_this menu;
        }
        Else
        {
                Load encouragement_screen;
                Play encouragement_sound.wav;
                Select object;
        }
```

Figure 4.60: Pseudocode for *Magic Box* exercise

When the *Get It* exercise is selected, Jane and a girl with a missing body part will display. Two pictures, each consisting of a body part, are placed on the left and right sides of the girl. Each picture is held by two clips as shown in Figure 4.61 (a). All the pictures used are based on the *Body Part* module under the *Learn with Fun* module. The proposed system randomly selects a missing body part from the girl, in this example, MOUTH, and then randomly places the corresponding missing part in one of the pictures. The remaining picture is filled by a randomly picked body part. Dr. John will ask the children to find the missing part and pull the correct picture down. Dr. John will respond “This is not the missing part. Please try again.” when the children are not able to solve the problem (see Figure 4.61 (b)). The proposed system will then select another two objects from the *Body Part* module randomly. However, one of the objects will still be a MOUTH and the other object can be any body part selected by the proposed system using a uniform randomisation algorithm (see Figure 4.61 (c)). The children will need to solve the problem to progress. If he manages to give the correct answer, the complete figure of the girl will appear, and Dr. John will say “Well done!” (see Figure 4.61 (d)). Figure 4.62 shows the pseudocode for the *Get It* exercise.

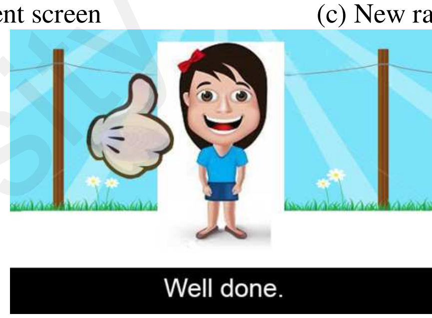


(a) Problem scenario



(b) Encouragement screen

(c) New randomly selected object



(d) Compliment screen

Figure 4.61: *Get It* exercise

```
Start getIt_exercise;
Select girl_with_missing_part;
Select bodypart;
Load scenario_screen;
Play scenario_sound.wav;

While no picture is pulled or idle more than 3 seconds
        {
                Load scenario_screen;
                Play scenario_sound.wav;
        }

        If right picture is pulled;
        {
                Load wellDone_screen;
                Play wellDone_sound.wav;
                Load can_you_do_this menu;
        }
        Else
        {
                Load encouragement_screen;
                Play encouragement_sound.wav;
                Load scenarioWithNewChoice_screen;
                Play scenario_sound.wav;
        }
```

Figure 4.62: Pseudocode for *Get It* exercise

4.5 Assessment Modules

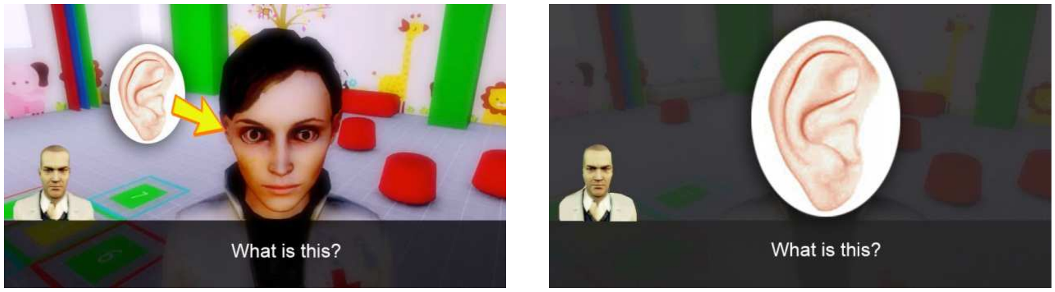
Assessment Modules are used to evaluate the knowledge transfer of language and communication, cognitive and psychomotor development for children. This section represents a significant step towards reaching objective 3 (see section 1.4). There are two types of assessments: *Virtual Game Assessment* and *Physical Game Assessment*. *Virtual Game Assessment* evaluates the children's learning outcomes via VLE whereas *Physical Game Assessment* assesses their knowledge transfer through classroom games. The assessments are based on recommendations of suitability by the majority of Klang Valley preschools surveyed. The teacher has to ensure that a child has completed the *Learn with Fun, Move Your Body,* and *Mind Games* modules before he enrols in the assessment modules.

4.5.1 Virtual Game Assessment

There are five assessment modules in *Virtual Game Assessment*: *Body Journey*, *Colour World*, *House of Shape*, *Number Hut*, and *Treasure Hunt*. All modules are designed based on the proposed syllabus in the *Learn with Fun* module (see Table 4.4), except for *Treasure Hunt*, which is based on the *Move Your Body* module. *Body Journey* is used to evaluate the recognition of human body parts whereas *Colour World* is used to examine the ability to differentiate colours. *House of Shape* assesses children on various shapes while *Number Hut* assesses them on number recognition and counting skills. Finally, *Treasure Hunt* evaluates psychomotor skills. All the assessments are used independently of each other and the teacher is free to choose any of the abovementioned assessments for evaluation purposes.

Figure 4.63: The menu of *Body Journey*

Figure 4.63 shows the *Body Journey* module with three assessments: *Body Quiz, Magic Tree* and *Fix Me. Body Quiz* assessment is used to examine the knowledge of human body parts whereas *Magic Tree* and *Fix Me* are used to examine problem solving skills.



(a) Dr. John and Miss Daisy (b) Assessment question

Figure 4.64: *Body Quiz* assessment

When the *Body Quiz* module is selected, Dr. John and Miss Daisy are shown. The assessment randomly selects five out of the twelve objects from the *Body Part* module in the *Learn with Fun* module. Dr. John will ask the children to name the shown body part, for example an *Ear*, as depicted in Figure 4.64 (a). A screen that focuses on the *Ear* is then shown (see Figure 4.64 (b)). The proposed system will wait for a voice input from the children. The teacher needs to guide the children to respond to the proposed system. Dr. John will repeat the question after three seconds if the assessment does not receive a response. The assessment will automatically continue to the next question if a response (voice) is detected. If no response is detected after the repeat, the proposed system will automatically continue to the next question after three seconds. The assessment is considered completed if all the five questions have been presented. The proposed system will record the performance of the children for each question by using 1 for correct answer and 0 for incorrect answer or no answer. After that, the *Body Journey* menu will appear automatically (see Figure 4.63). Figure 4.65 shows the pseudocode for *Body Quiz* assessment.

```
Start body_quiz_assessment;
Set count equals to 5;

While count not equal to 0
{
        Select bodyPart;
        Load selectedBodyPart_screen;
        Play question_sound.wav;

        If right answer is received
        {
                Set mark equals to 1;
                Deduct count by 1;
        }
        If received_sound is wrong;
        {
                Set mark equals to 0;
                Deduct count by 1;
        }
        If idle more than 3 seconds;
        {
                Load selectedBodyPart_screen;
                Play question_sound.wav;

                If right answer is received
                {
                        Set mark equals to 1;
                        Deduct count by 1;
                }
                Else
                {
                        Set mark equals to 0;
                        Deduct count by 1;
                }
        }
}

Load body_journey menu;
```

Figure 4.65: Pseudocode for *Body Quiz* assessment

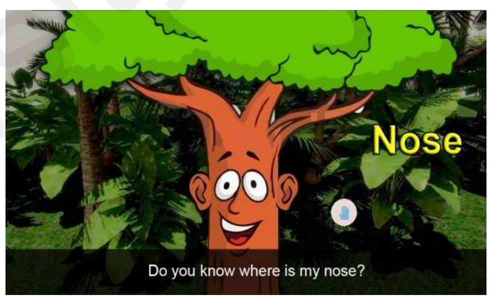


Figure 4.66: *Magic Tree* assessment

When *Magic Tree* is selected, Whooby, the tree avatar is shown. The proposed system will randomly select three out of a total of seven possible questions (Hair, Eye, Nose, Ear, Mouth, Tongue, Teeth) for assessment. Whooby will ask the children to touch a body part, for example a *Nose*, as depicted in Figure 4.66. The respective word for *Nose* will be placed on the right side of the screen. Then, the proposed system will wait for a gesture input from the children. The same response and detection method as that of the *Warm Up* module will be used. The teacher needs to guide the children to choose only one option in the proposed system. The assessment is considered completed if all three questions have been presented. The marking scheme for *Magic Tree* assessment is similar to the *Body Quiz* assessment. After that, the *Body Journey* menu will appear automatically (see Figure 4.63). Figure 4.67 shows the pseudocode for *Magic Tree* assessment.

```
Start magic_tree_assessment;
Set count equals to 3;

While count not equal to 0
{
        Select bodyPart;
        Load selectedBodyPart_screen;
        Play question_sound.wav;

        If right bodyPart is selected
        {
                Set mark equals to 1;
                Deduct count by 1;
        }
        If selected_bodyPart is wrong;
        {
                Set mark equals to 0;
                Deduct count by 1;
        }
        If idle more than 3 seconds;
        {
                Load selectedBodyPart_screen;
                Play question_sound.wav;

                If right bodyPart is selected
                {
                        Set mark equals to 1;
                        Deduct count by 1;
                }
                Else
                {
                        Set mark equals to 0;
                        Deduct count by 1;
                }
        }
}
Load body_journey menu;
```

Figure 4.67: Pseudocode for *Magic Tree* assessment

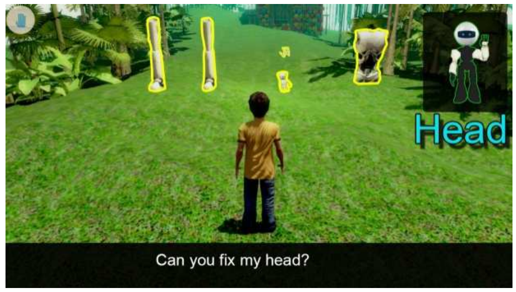


Figure 4.68: *Fix Me* assessment

When *Fix Me* is selected, a robot avatar is shown. The robot will ask the children to fix its body part, for example *Head*, by dragging the part to the body frame that is placed at the top right corner as shown in Figure 4.68. The respective word for *Head* will be placed below the body frame. There are a total of five body parts, which are head, body, hand, fingers, and legs. The proposed system will randomly select two body parts for assessment. Each attempt only allows for the placing of one body part (i.e. legs). The teacher needs to guide the children to place only one body part at a time. The response and detection method, and the assessment scheme similar used are the same as that for *Magic Tree*. The assessment is considered completed if all two questions have been presented. After that, the *Body Journey* menu will appear automatically (see Figure 4.63). The assessment menus (see Figure F19), activities (see Figure F20, F21, & F22), and corresponding pseudocode for the remaining assessments (i.e. *Colour World*, *House of Shape*, and *Number Hut*) are attached in the Appendix F (see Figure F23).

Figure 4.69: The menu of *Treasure Hunt*

Figure 4.69 shows the *Treasure Hunt* assessment. The assessment consists of *Forest Adventure*, *River Adventure*, and *Treasure Box*. All these assessments are used to examine the children's psychomotor skills taught in the *Move Your Body* module.

Figure 4.70: The menu of *Forest Adventure*

Figure 4.70 shows the *Forest Adventure* assessment. The assessment consists of *Run*, *Kick*, *Hop*, and *Balance*. All these assessments are used to examine psychomotor skills, cognitive skills such as decision-making skills (*Run* assessment), and problem solving skills (*Kick* and *Hop* assessments).


```
Start run_assessment;
Load run_screen;
Play run_sound.wav;

If valid movement is received;
{
        Set mark equals to 1;
}
Elseif idle more than 3 seconds
{
        Load run_screen;
        Play run_sound.wav;
        If valid movement is received;
        {
                Set mark equals to 1;
        }
        Else
        {
                Set mark equals to 0;
        }
}
Load forest_adventure menu;
```

(a) Problem scenario (b) Pseudocode

Figure 4.71: *Run* assessment and its pseudocode

When *Run* is selected, Dr. John and James are shown. Dr. John will ask the children to run away because there is a dinosaur! (see Figure 4.71 (a)). The children have to run to the safe area (a rectangular area that highlighted in orange colour) indicated by a yellow arrow. The teacher needs to guide the children to respond to the proposed system. The assessment is considered complete if the children have reached the safe area. After that, the *Forest Adventure* menu will appear automatically (see Figure 4.70). Figure 4.71 (b) shows the pseudocode for *Run* assessment.

When *Kick* is selected, Dr. John, James and three logs are shown. Dr. John will ask the children to kick away the logs that block the way (see Figure 4.72 (a)). The teacher needs to guide the children to respond to the proposed system. The assessment is considered complete if the children have kicked away all three logs. After that, the *Forest Adventure* menu will appear automatically (see Figure 4.70). Figure 4.72 (b) shows the pseudocode for *Kick* assessment.


```
Start kick_assessment;
Load kick_scenario_screen;
Play kick_scenario_sound.wav
Set count equals to 3;

While count not equal to 0
{
        If valid movement is received;
        {
                Set mark equals to 1;
        }
        Elseif idle more than 3 seconds
        {
                Load kick_scenario_screen;
                Play kick_scenario_sound.wav

                If valid movement is received;
                {
                        Set mark equals to 1;
                }
                Else
                {
                Set mark equals to 0;
        }
}
Load forest_adventure menu;
```

(a) Problem scenario (b) Pseudocode

Figure 4.72: *Kick* assessment and its pseudocode

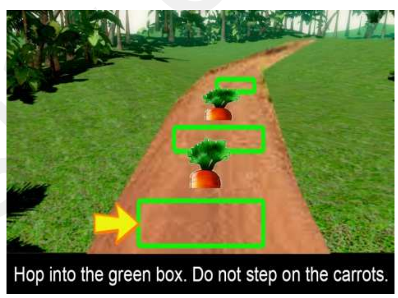


Figure 4.73: *Hop* assessment

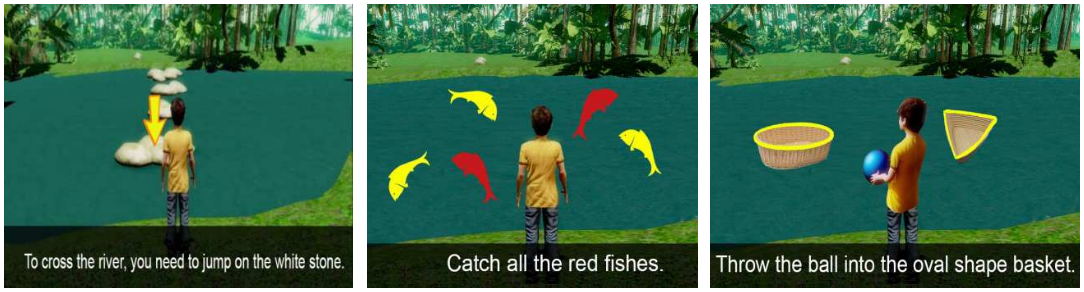
When *Hop* is selected, Dr. John, James, and three green boxes are shown. Dr. John will ask the children to hop into the green box placed between the carrots (see Figure 4.73). The teacher needs to guide the children to respond to the proposed system. The assessment is considered complete if the children have kicked away all three logs. After that, the *Forest Adventure* menu will appear automatically (see Figure 4.70). The pseudocode for *Hop* assessment is similar with *Kick* assessment.

Figure 4.74: *Balance* assessment

When *Balance* is selected, Dr. John, and James are shown. Dr. John will ask the children to pass through the moving gate by following the action demonstrated by the kid placed at the top right corner of the screen (see Figure 4.74). The teacher needs to guide the children to respond to the proposed system. The assessment is considered complete if the children have passed through the gate. After that, the *Forest Adventure* menu will appear automatically (see Figure 4.70). The pseudocode for *Balance* assessment is similar with *Run* assessment.

Figure 4.75: The menu of *River Adventure*

Figure 4.75 shows the *River Adventure* assessment. The assessment consists of *Jump*, *Catch*, and *Throw*. All these assessments are used to examine the psychomotor skills of children and also their cognitive skills such as decision-making skill (*Jump* assessment) and problem solving skills (*Catch* and *Throw* assessments). For *Catch* and *Throw* assessments, the children have to use their recognition skills to solve the given problem.



(a) *Jump* scenario (a) *Catch* scenario (a) *Throw* scenario

Figure 4.76: *Jump*, *Catch*, and *Throw* assessments

Figure 4.76 shows the *Jump*, *Catch*, and *Throw* assessments. Again, the teacher needs to guide the children to respond to the proposed system. For *Jump* assessment, Dr. John will ask the children to jump onto the white stone to cross the river (see Figure 4.76 (a)). A yellow arrow is used to show the direction towards the white stone. The assessment is considered complete if the children have reached the opposite side of the river.

In *Catch* assessment, the proposed system will randomly select two colours for the fish to appear in the assessment. The range of colours tested here was taught in the *Colour* module under the *Learn with Fun* module. Dr. John will ask the children to catch the fish of a particular colour. That colour is randomly selected by the proposed system, for example, the red fish in Figure 4.76 (b). The assessment is considered completed if the children have caught all the red fish.

For *Throw* assessment, the proposed system will randomly select two baskets of different shapes for assessment. The shapes of baskets have been taught in the *Shape* module under *Learn with Fun* module. Dr. John will ask the children to throw a ball into a basket, for example an oval shape basket (see Figure 4.76 (c)). The shape of each basket is highlighted by a yellow outline. The assessment is considered completed if the children have thrown the ball.

The *River Adventure* menu will appear automatically (see Figure 4.75) when the assessment is completed. The pseudocode for *Jump* assessment is similar with the *Run* assessment whereas the pseudocode for *Catch* and *Throw* assessments are similar to the *Kick* assessment.

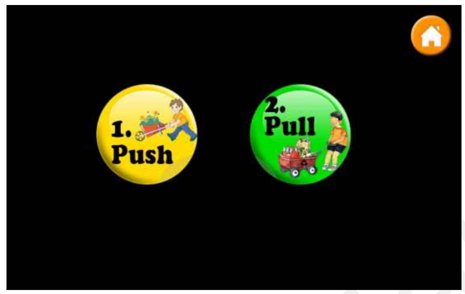


Figure 4.77: The menu of *Treasure Box*

Figure 4.77 shows the *Treasure Box* assessment. The assessment consists of *Push* and *Pull*, which are used to examine the psychomotor skills of children and their decision-making skills.

(a) *Push* scenario

(b) *Pull* scenario

Figure 4.78: *Push* and *Pull* assessments

Figure 4.78 shows the *Push* and *Pull* assessments. For *Push* assessment, Dr. John will ask the children to push the wagon to get the treasure box (see Figure 4.78 (a)). A yellow arrow is used to show the direction towards the treasure box. The assessment is considered completed when the children have reached the treasure box. On the other hand, Dr. John will ask the children to pull the wagon to cross the bridge in the *Pull* assessment (see Figure 4.78 (b)). A yellow arrow is used to point to the direction to the other end of the bridge. The assessment is considered completed if the children have reached the other end of the bridge. The *Treasure Box* menu will appear automatically (see Figure 4.77) when the assessment is completed. The pseudocode for *Push* and *Pull* assessment is similar to *Run* assessment.

4.5.2 Physical Game Assessment

There are seven assessments in *Physical Game Assessment*, which are *Building Blocks*, *Card Game*, *Counting Game, Puzzle*, *Question and Answer* (*Q & A*) *Game*, *Ball Skills* and *Leg Game*. All the assessments are based on the proposed syllabus in the *Learn with Fun* module (see Table 4.4) and the *Move Your Body* module (see Table 4.5). *Building Blocks* is used to evaluate the recognition of colours and shapes, problem solving and psychomotor skills (hand-eye coordination). *Card Game* is used to examine word recognition for colours, shapes, and numbers. *Counting Game* assesses counting skills. *Puzzle* tests word recognition for human body part while *Q & A Game* evaluates communication skills. *Ball Skills* and *Leg Games* are used to evaluate psychomotor skills related with hands and legs. These two assessments are designed based on the modified version of Test of Gross Motor Development, Second Edition (TGMD-2) (Ulrich, 2000). Moreover, these two assessments are those accepted and recommended by the majority of the preschools surveyed in the Klang Valley, Malaysia. All the assessments are independent and the teacher is free to choose any of them for evaluation purposes.

Table 4.6: *Building Blocks* assessment

Level of difficulty	3D model construction	2D model construction
Level 1		
Number of blocks used	**4**	**7**
Level 2		 2B
Number of blocks used	**7**	**9**
Level 3		 3B
Number of blocks used	**9**	**11**

Table 4.6 shows the *Building Blocks* assessment, which consists of three levels of difficulty. Each level contains two types of model: two-dimensional (2D) and three-dimensional (3D). The number of blocks used increases by level. For example, Level 1A requires 4 blocks, Level 2A needs 7 blocks while Level 3 uses 9 blocks. All the six models are presented to the children via photographs. They are required to construct the respective model based on the given photographs. The correct block construction will be marked as 1 for problem solving under cognitive skill assessment whereas 0 is used for incomplete or wrong construction. In addition, the child will also receive 1 mark each for colour and shape recognition. For incomplete or wrong construction, the child will also receive 1 mark each for colour and shape recognition if he/she chooses all the

required blocks correctly. Conversely, 0 will be given for an incorrect choice of block for both colour and shape recognition. The assessment is considered completed if the child has finished all six models

(a) Word recognition for colour

(b) Word recognition for shape

(c) Word recognition for number

Figure 4.79: *Card Game* assessment

Figure 4.79 shows the *Card Game* assessment for word recognition. *Colour*'s word recognition uses seven toys and seven cards (each written with the name of one colour) (see Figure 4.79 (a)) whereas *Shape* assessment utilises six building blocks and six cards (see Figure 4.79 (b)) and *Number* assessment uses 11 magnetic numbers (number 10 consists of two magnetic numbers which are 1 and 0) and ten cards (see Figure 4.79 (c)). The teacher will randomly select five objects for the use of the assessment. The child needs to match the correct card with the given object. Here is an example of how it works. Assume a child is taking the assessment for *Colour*'s word recognition. A red pair of scissor is given to the child, and he/she needs to look for the card written with *red* and place it next to the scissors. Each correct match will be marked as 1 whereas 0 for wrong match. The assessments for word recognition of *Shape* and *Number* are similar to that of *Colour*. The assessment is considered completed if the child has finished all five matching of cards.

Figure 4.80: *Counting Game* assessment

Figure 4.80 shows the *Counting Game* assessment. There are ten wood pieces, each illustrated with a different number of objects, from one to ten (1-10). The teacher will randomly select five wood pieces for assessment. The child needs to count the number of objects on the given piece of wood. Each correct count will be marked as 1 and 0 for the wrong count. The assessment is considered completed if the child has finished the counting for all five wood pieces.

Figure 4.81: *Puzzle* assessment

Figure 4.81 shows the *Puzzle* assessment. There are twelve pairs in the puzzle, with each pair consisting of an illustrated body part and its respective name. The teacher will randomly select five pairs for assessment. The child will be given ten puzzle pieces, five illustrated with individual body parts, and another five, with the body part's name. The child needs to match the piece of puzzle with a body part, such as mouth with the respective body part's name (Mouth). Each correct matching will be marked as 1 and 0 is given for an incomplete or wrong match. The assessment is considered completed when the child has finished matching all five pairs.

Q & A Game is an assessment of language and communication skills. With the teacher and the children in a quiet room, one child at a time will be called out for the assessment. The teacher starts the assessment by randomly pointing to one body part (i.e. hand) of the child. The child has to tell the teacher the name of the body part and its function such as writing and touching. The assessment is considered completed when each child has finished all the five questions. A correct recognised body part will be marked as 1 and 0 is given for a wrong answer or when no answer is given. For the function of body part, each correct answer will be marked as 1, and 0, for a wrong answer or when no answer is given.

Ball Skills consists of two psychomotor skills assessments that are related with hands and legs. The first assessment is ball catching and throwing. This assessment requires two (2) to ten (10) children playing in a group. They are divided into two groups (Group A and Group B) and each group will have one (1) to five (5) player(s). Two lines, which are 1.5 metres apart, are marked. Each group stands behind one of the lines (see Figure 4.82 (a)). The teacher gives a 4-inch plastic ball to the first child of Group A (A1) and asks him to throw the ball to the first child of Group B (B1) who is standing in front of him. B1 has to catch the ball thrown by A1. A demonstration for the respective skills is depicted in Figure 4.82 (b)). Then, B1 throws the ball back to A1. The game will continue with the second child from each of the group. Each child is given a second chance for catching a ball and throwing a ball if he/she fails the first time. The assessment is considered completed when the last child of Group A has caught the ball thrown by the last child of Group B. The assessment scheme is based on the performance criteria shown in Table 4.7. For ball catching, the successful completion (ball is caught by hands) will be marked ‘1’ and ‘0’ is for a failed attempt (missing the ball). Similarly, the correct throw (the ball is thrown overhead with two hands) will be marked ‘1’ with ‘0’ for an incorrect throw. If a child refuses to take part in the assessment, his/her performance will be recorded as ‘N’, which stands for no participation.

(a) Children stands behind the line

(b) Demonstration

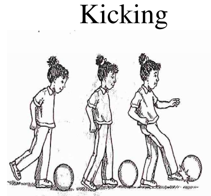
Figure 4.82: ***Ball Catching/Throwing*** **assessment**

Table 4.7: Performance criteria for ball catching and throwing

Psychomotor skill	Performance criteria
Throw a ball	1. Hold the ball with two hands. 2. Throw the ball overhead to the child who stands in front.
Catch a ball	1. Two hands are in front of the body. 2. Pay attention to the child who is going to throw the ball. 3. Catch the ball with two hands.

The second assessment is ball passing (kicking). Likewise, this assessment requires two (2) to ten (10) children to play as a group. The setting of the game is similar with *Ball Catching/Throwing* (see Figure 4.82 (a)). The teacher will ask the first child of Group A (A1) to use the left leg and kick the ball to the first child of Group B (B1) that is standing in front of him. Then, B1 will kick back the ball to A1. The game will continue with the second child from each of the groups. Each child is given a second chance for passing the ball to the right child if he/she fails the first time. The assessment on kicking using left leg is considered complete if the last child from group B has passed the ball back to the last child from group A. The children will then continue the game with the right leg. The assessment scheme is based on the performance criteria shown in Table 4.8. The successful completion will be marked as ‘1’, ‘0’ is for a failed attempt and ‘N for no participation.

Table 4.8: Performance criteria for ball passing (kicking) (Ulrich, 2000)

Psychomotor skill	Performance criteria
Kicking 	1. Non-kicking foot placed even with or slightly in the back of the ball. 2. Kick the ball to the child who stands in front.

Leg Games consist of four psychomotor skills assessments, which are one leg stand, running, jumping, and hopping. For the one leg stand (static balance) assessment, the children will be asked to stand using their left legs when the teacher blows a whistle. They are allowed to use their hands to balance their bodies. The assessment of left leg is considered complete when the teacher blows the whistle after five (5) seconds. The assessment scheme is based on the performance criteria shown in Table 4.9. Again, a successful completion will be marked as ‘1’, a failed attempt as ‘0’, and for no participation as ‘N’. The assessment will then continue for the right leg. The assessment is considered complete if the children have completed the assessments for their left and right legs.

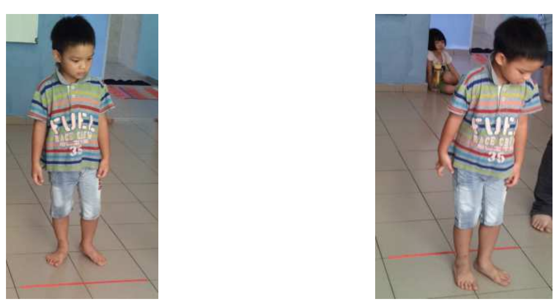
Table 4.9: Performance criteria for one leg stand

Psychomotor skill	Performance criteria
One leg stand 	1. Lift up the right leg and stand on left leg. 2. Hold the position for at least five (5) seconds. 3. Lift up the left leg and stand on right leg. 4. Hold the position for at least five (5) seconds.

Table 4.10: Performance criteria for running (Ulrich, 2000)

Psychomotor skill	Performance criteria
Running 	1. Arms move in opposition to legs, elbows bent. 2. Brief period where both feet are off the ground. 3. Narrow foot placement landing on heel or toe. 4. Non-support leg bent approximately 90 degrees.

A rectangular play compound with a perimeter of approximately 16 metres is used for the running assessment. Each child will start to run as fast as possible when the teacher blows the whistle. The assessment is considered completed when the child reaches the starting point (one lap). The assessment scheme is based on the performance criteria shown in Table 4.10. A successful completion will be marked as ‘1’, a failed attempt as ‘0’, and for no participation as ‘N’. The time used for completing the run for each child will also be recorded.



(a) Prepare to jump forward (b) Prepare to jump backward

Figure 4.83: Jumping assessment

Figure 4.83 shows the third assessment, which is jumping. The floor is marked with a horizontal line. Each child needs to jump forward and backward at least one time. The assessment scheme is based on the performance criteria shown in Table 4.11. A successful completion will be marked as '1', a failed attempt as '0', and for no participation as 'N'.

Table 4.11: Performance criteria for jumping (Ulrich, 2000)

Psychomotor skill	Performance criteria
Jumping	1. Take off and land on both feet simultaneously. 2. Arms are thrust downward during landing.

Figure 4.84: Hopping assessment

Figure 4.84 shows the fourth assessment, hopping, which uses the same setting as that for the jumping assessment. Each child needs to hop over the line with the left leg and then the same with right leg. The assessment scheme is based on the performance criteria shown in Table 4.12. A successful completion (without stepping the line) will be marked as '1', a failed attempt as '0', and for no participation, as 'N'.

Table 4.12: Performance criteria for hopping (Ulrich, 2000)

Psychomotor skill	Performance criteria
Hopping	1. Non-support leg swings forward in pendulum fashion to produce force. 2. Foot of non-support leg remains behind body. 3. Arms flexed and swing forward to produce force. 4. Takes off and lands on preferred foot. 5. Takes off and lands on non-preferred foot

4.6 Summary

Two surveys were used to identify the system requirement and collect the feedback for the developed prototypes. A GBL system, namely *myKinderLand* was developed based on the survey results to evaluate the proposed framework in promoting GBL for language and communication, cognitive, and psychomotor development of preschool children. The system architecture consists of three main components: Learning System, Application Manager, and Storage Manager. The Learning System is responsible for the display as well as the voice and gesture detection via a dialog system and an interaction system. The Application Manager provides the appropriate module to the Xbox console and manages the communication between the Learning System and Storage Manager. The Storage Manager is used to handle the data query, accessing and storing.

myKinderLand comprises two modules, learning modules, and assessment modules. The learning modules convey the language and communication, cognitive, and psychomotor elements to preschool children where as the assessment modules are used to evaluate knowledge transfer of preschool children after using the learning modules to learn.

The next chapter will explain the system testing and evaluation in details. A testing of voice and gesture recognition was conducted at one of the selected preschools. The participants consist of sixteen (16) 4-year-old preschool children (8 boys and 8 girls). For the system evaluation, a total of 81 preschool children age 4 were invited for the GBL intervention and learning performance evaluation. They were divided into two groups — the control and experimental groups. The result were analysed and compared in several areas, including language and communication as well as the development of cognitive and psychomotor skills.

CHAPTER 5:System Testing and Evaluation

5.1 Introduction

This chapter presents the system testing and evaluation results for the proposed learning system. The first section discusses the testing for speech and gesture recognition, followed by system integration testing. The second section analyses the proposed system in the language and communication, cognitive and psychomotor development of preschool children. A chapter summary is presented in the last section.

5.2 System Testing

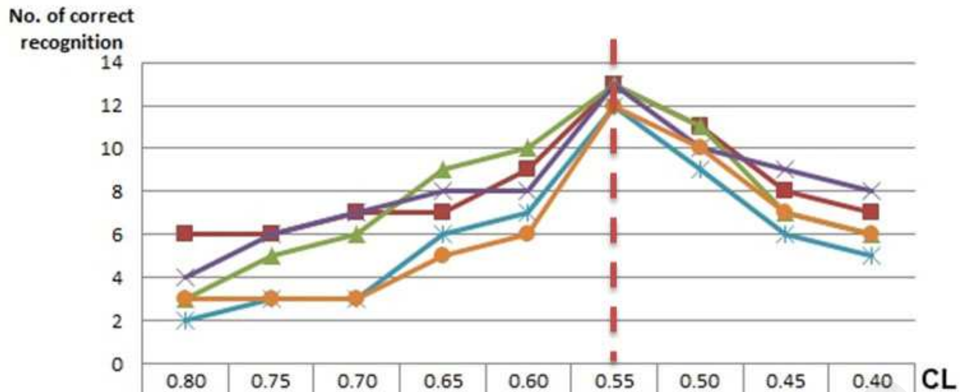
This section discusses the system testing for the proposed learning system, which includes speech recognition, gesture recognition and system integration testing. Speech recognition testing focused on the level of acceptance (confidence level) whereas the testing of gesture recognition aimed at skeletal tracking, which tracks the movement of the preschool children. The system integration testing evaluates the proposed learning system against the specified requirements.

5.2.1 Testing for Speech Recognition

Although the advancement in technology has improved the performance of speech recognition remarkably, some variations in speech such as speaker, speaking rate, vocal effort, and speaking style still remain unsolved (Benzeghiba et al., 2007; Deng, Hinton, & Kingsbury, 2013b; Li, Han, & Narayanan, 2013). Children's speech has higher pitch as compared to adult's speech (Gerosa, Giuliani, & Brugnara, 2007) mainly due to the former having a shorter vocal tract and vocal folds (Benzeghiba et al., 2007).

By considering the above-mentioned issues, a preliminary test was conducted at one of the selected preschools. The test involved a total of sixteen (16) 4-year-old children (8 boys and 8 girls). It aimed to examine the level of acceptance (the confidence level (CL)) for the speech recognition function of the proposed learning system, with value ranging from 0 to 1, where 0 represents the lowest confidence, and 1, the highest. CL is not the indicator for speech accuracy but works as a mechanism for deciding the best acceptance level of speech recognition without losing clarity. The proposed system translates the detected speech into text. The speech recognition is correct when the translated text is the same as the spoken speech; otherwise, the speech recognition is incorrect.

Sixteen (16) children were taught to read all the words in *Learn with Fun* module (see Table 4.1 in Chapter 4). Six words (Red, Star, Seven, Three, and Teeth) were taken from the *Learn with Fun* module for the test based on the level of difficulty in their pronunciation. *Red* was considered an easy word because it had only one syllable. *Star* and *Seven* were classified as medium level because some of the children had problems pronouncing the S consonant sound as all of them were not native English speakers. *Three* and *Teeth* are the most difficult words due to the *th* and long vowel sounds. Figure 5.1 shows the testing result of speech recognition for CL value ranging from 0.4 to 0.8. The number of correct recognition increases with decreasing CL value. Nevertheless, the number of correct recognition decreases when CL is below 0.5. When CL=0.55, the correct recognition rate is between 75% (12/16) and 81% (13/16). Therefore, the best CL value for the group of 4 years old children is 0.55.

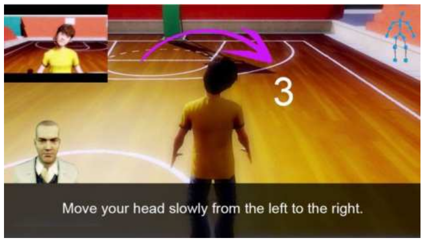


	0.80	0.75	0.70	0.65	0.60	0.55	0.50	0.45	0.40
Red	6	6	7	7	9	13	11	8	7
Star	3	5	6	9	10	13	11	7	6
Seven	4	6	7	8	8	13	10	9	8
Three	2	3	3	6	7	12	9	6	5
Teeth	3	3	3	5	6	12	10	7	6

Figure 5.1: Testing of confidence level (CL) of speech recognition

5.2.2 Testing for Gesture Recognition

Three tests, namely head recognition, hand recognition, and leg recognition, were conducted for the testing of gesture recognition. The tests aimed to examine the ability of the proposed system to perform the core functions of recognising head, hand and leg movements, respectively. The above-mentioned group of children were invited for these tests. Screenshots of the test for head, hand, and leg recognition are in Figure 5.2 (a), (b), and (c), respectively. All the children and their movements were successfully recognised by the proposed system regardless of height and gender. The skeleton, which was placed on the top right corner in Figures 5.2 (a), (b), and (c), was to show the tracking of a child's movement.



(a) Testing of Head Recognition

(b) Testing of Hand Recognition

(c) Testing of Leg Recognition

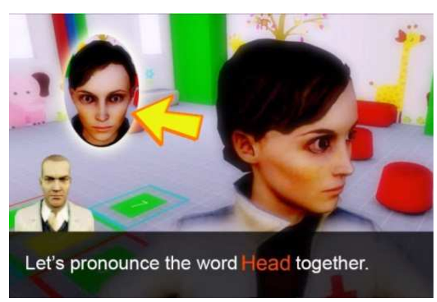
Figure 5.2: Testing of Gesture Recognition

5.2.3 Testing for System Integration

The system integration testing was conducted for both the learning and assessment modules.

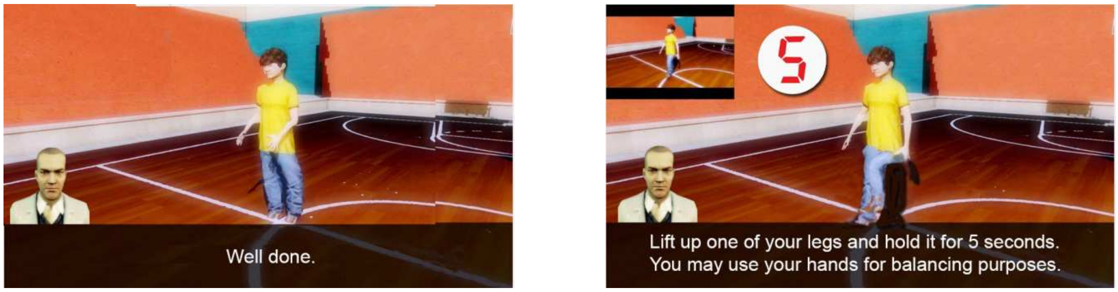
5.2.3.1 Testing for Learning Modules

(a) Compliment screen for correct speech



(b) Repeat instruction for incorrect speech

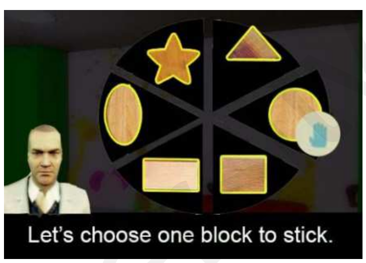
Figure 5.3: Testing of *Learn with Fun* module



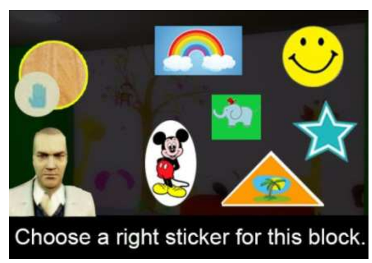
(a) Compliment screen for correct movement (b) Repeat instruction for incorrect movement

Figure 5.4: Testing of *Move Your Body* module

The testing of word pronunciation was executed in each category of the *Learn with Fun* module. If the speech was recognised correctly, a compliment screen will be displayed (see Figure 5.3 (a)); else the respective instruction was repeated (see Figure 5.3 (b)). For the *Move Your Body* module, similar feedback was given to the preschool children for correct (see Figure 5.4 (a)) and incorrect movements (see Figure 5.4 (b)).

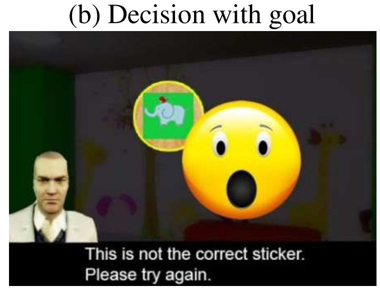


(a) Decision without specific goal



(b) Decision with goal

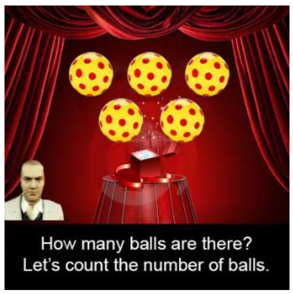
(c) Compliment screen



(d) Encouragement screen

Figure 5.5: Testing of *Make Your Choice* (*Mind Games* module)

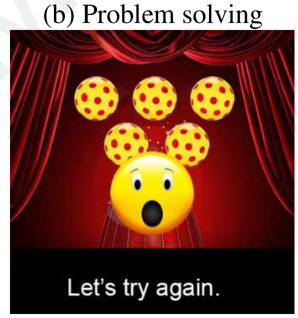
The testing of object selection and movement was done for the *Mind Games* module, which consists of *Make Your Choice* and *Can you do this?*. Figures 5.5 (a) and (b) show the object movement testing for the *Make Your Choice* exercise. A compliment screen was shown if the correct answer was given (see Figure 5.5 (c)); otherwise, encouragement screen was shown (see Figure 5.5 (d)). The object selection testing for *Can you do this?* is depicted in Figures 5.6 (a) and (b). As with the other tests, a compliment screen will be shown for a correct answer (see Figure 5.6 (c)), and an encouragement screen shown for wrong answer (see Figure 5.6 (d)).



(a) Problem screnario

(b) Problem solving

(c) Compliment screen

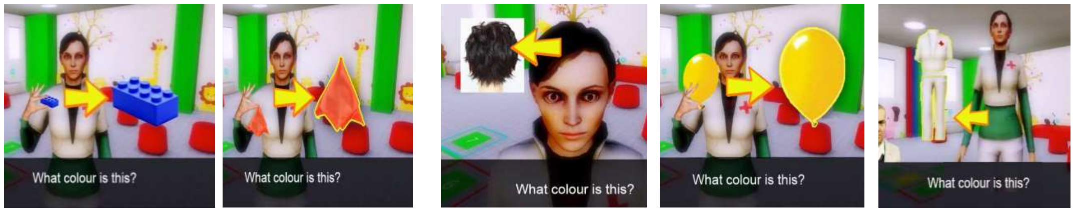


(d) Encouragement screen

Figure 5.6: Testing on *Can you do this?* (*Mind Games* module)

5.2.3.2 Testing for Assessment Modules

The testing focused voice recognition, object selection/movement, gesture recognition and record saving. The testing for voice recognition involved five assessments, namely *Body Quiz (Body Journey)*, *Colour Quiz (Colour World)*, *Shape Quiz (House of Shape)*, and *Number Hut (Number Quiz).* Figure 5.7 (a) shows the testing of the *Colour Quiz* assessment. The system recorded 1 for a correct answer (see Figure 5.7 (b)), and 0 for a wrong answer or for a no speech detected condition (see Figure 5.7 (c)).



a) Assessment scenario


```
<xml>
        <Name>ABC</Name>
                <ColourWorldModule>
                        <ColourQuiz>
                                <Task1>
                                        <Result>1</Result>
                                </Task1>
                                <Task2>
                                        <Result>1</Result>
                                </Task2>
                                <Task3>
                                        <Result>1</Result>
                                </Task3>
                                <Task4>
                                        <Result>1</Result>
                                </Task4>
                                <Task5>
                                        <Result>1</Result>
                                </Task5>
                        </ColourQuiz>
                </ColourWorldModule>
</xml>
```

```
<xml>
        <Name>ABC</Name>
                <ColourWorldModule>
                        <ColourQuiz>
                                <Task1>
                                        <Result>0</Result>
                                </Task1>
                                <Task2>
                                        <Result>0</Result>
                                </Task2>
                                <Task3>
                                        <Result>1</Result>
                                </Task3>
                                <Task4>
                                        <Result>0</Result>
                                </Task4>
                                <Task5>
                                        <Result>1</Result>
                                </Task5>
                        </ColourQuiz>
                </ColourWorldModule>
</xml>
```


b) Correct response c) Incorrect response

Figure 5.7: Testing of the *Colour Quiz* assessment

a) Assessment scenario


```
<xml>
        <Name>ABC</Name>
                <HouseOfShapeModule>
                        <KeepTheToys>
                                <Task1>
                                        <Result>1</Result>
                                </Task1>
                                <Task2>
                                        <Result>1</Result>
                                </Task2>
                                <Task3>
                                        <Result>1</Result>
                                </Task3>
                                <Task4>
                                        <Result>1</Result>
                                </Task4>
                                <Task5>
                                        <Result>1</Result>
                                </Task5>
                        </KeepTheToys>
                </HouseOfShapeModule>
</xml>
```

```
<xml>
        <Name>ABC</Name>
                <HouseOfShapeModule>
                        <KeepTheToys>
                                <Task1>
                                        <Result>0</Result>
                                </Task1>
                                <Task2>
                                        <Result>1</Result>
                                </Task2>
                                <Task3>
                                        <Result>0</Result>
                                </Task3>
                                <Task4>
                                        <Result>0</Result>
                                </Task4>
                                <Task5>
                                        <Result>1</Result>
                                </Task5>
                        </KeepTheToys>
                </HouseOfShapeModule>
</xml>
```


b) Correct response c) Invalid response

Figure 5.8: Testing of the *Keep the Toys* assessment

The testing of object selection/movement was done for *Magic Tree* and *Fix Me (Body Journey)*, *Ball Game (Colour World)*, *Keep the Toys (House of Shape)*, and *Open Sesame* and *Let's Count (Number Hut)*. Figure 5.8 (a) shows the testing of *Keep the Toys*. Again, the system will record 1 for the correct movement (see Figure 5.8 (b)) and 0 for invalid movement or the no movement detected condition (Figure 5.8 (c)).

The testing of body movement was done for *Forest Adventure (Run, Kick, Hop, and Balance)*, *River Adventure (Jump, Catch, and Throw)*, and *Treasure Box (Push and Pull)*. The testing of the *River Adventure* module is depicted in Figure 5.9 (a). Again, the system recorded 1 for the correct movement (see Figure 5.9 (b)) and 0 for an invalid movement or no movement detected condition (Figure 5.9 (c)).

a) Assessment scenario

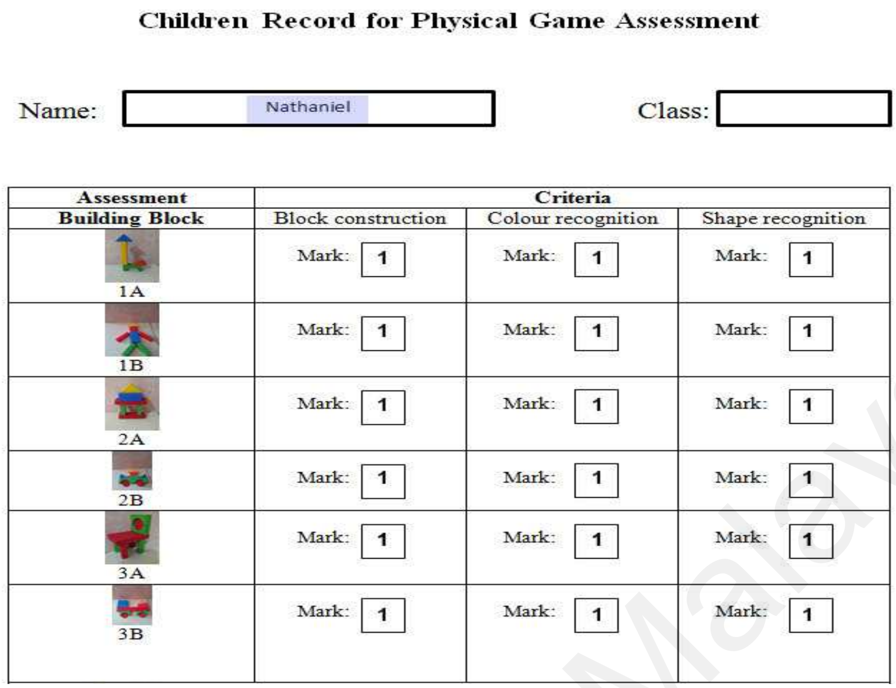

```
<xml>
        <Name>ABC</Name>
                <TreasureHuntModule>
                        <RiverAdventure>
                                <JumpAssessment>
                                        <Result>1</Result>
                                </JumpAssessment>
                        <RiverAdventure>
                </TreasureHuntModule>
</xml>
```


b) Correct response


```
<xml>
        <Name>ABC</Name>
                <TreasureHuntModule>
                        <RiverAdventure>
                                <JumpAssessment>
                                        <Result>0</Result>
                                </JumpAssessment>
                        <RiverAdventure>
                </TreasureHuntModule>
</xml>
```


c) Invalid response

Figure 5.9: Testing of the *River Adventure* assessment


Children Record for Physical Game Assessment

Name: Nathaniel   Class:

Assessment	Criteria		
Building Block	Block construction	Colour recognition	Shape recognition
1A	Mark: 1	Mark: 1	Mark: 1
1B	Mark: 1	Mark: 1	Mark: 1
2A	Mark: 1	Mark: 1	Mark: 1
2B	Mark: 1	Mark: 1	Mark: 1
3A	Mark: 1	Mark: 1	Mark: 1
3B	Mark: 1	Mark: 1	Mark: 1

Figure 5.10: Testing of saving record of *Physical Game Assessment*

The testing of saving record of *Physical Game Assessment*is depicted in Figure 5.10. There are seven assessments in *Physical Game Assessment*, which are *Building Blocks*, *Card Game*, *Counting Game, Puzzle*, *Question and Answer* (*Q & A*) *Game*, *Ball Catching/Throwing* and *Leg Game*. The system recorded the mark for each assessment.

5.2.3.3 Testing for System Reporting

The assessment result for three areas of development, language and communication, cognitive skills and psychomotor skills, are recorded. The grading and marking scheme used is as explained in Chapter 3 (see Table 3.8 and 3.9). *Excellent Performance* is for a score between 80 and 100 and five stars are rewarded. A score between 50 and 79 is *Average Performance* and three stars are rewarded. Lastly, a score below 50 is graded as *Low Performance*. A smiley face and a quote from Bigelow (2015) "*It works if you* *work it!*” are given for encouragement. The number of stars and smiley faces are used for illustration purposes and do not represent the actual score of a performance.

(a) Report card for boy (b) Report card for girl

Figure 5.11: The report card for language and communication performance

Figure 5.11 shows the testing for system output on the children's performance in language and communication. The upper part (“I can tell body parts” and etc.) displays the score for *Body Quiz*, *Colour Quiz*, *Shape Quiz*, and *Number Quiz* (*Virtual Game Assessment*) whereas the lower part (“I can recognise body parts” and etc.) shows the score for the *Card Game* and *Puzzle* (*Physical Game Assessment*). All the scores are converted to 100%. The conversion is done using the equation 5.1.

$$c = (a / b) \times 100\% \qquad (5.1)$$

Where c = score in percentage,

a = mark scored for a test, and

b = the total mark of a test

For example, if a child scored 4 out of 5 in *Body Quiz* assessment, the score, c = 4/5 x 100% = 80%. Five stars (*Excellent Performance*) will be displayed on the row of "I can tell body parts". Similarly, if a child scored 4 out of 5 in *Puzzle* assessment, five stars (*Excellent Performance*) will be displayed on the row of "I can recognise body parts".

(a) Report card for boy (b) Report card for girl

Figure 5.12: The report card for cognitive skills performance

Figure 5.12 shows the testing for system output on the children's performance in cognitive skills. The score collected from the assessments will be added and converted to 100%. The conversion is done using the equation below:-

$$j = [(d + f)/ (g + h)] \times 100\% \quad (5.2)$$

Where j = final score in percentage,

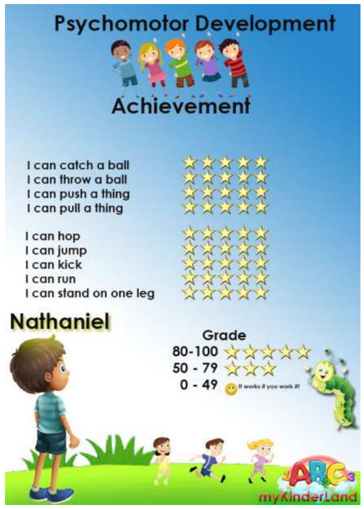
d, f = mark scored for a test, and

g, h = the total mark of a test

Table 5.1: Details of grading scheme for cognitive skill performance

I can work with body parts	d = mark scored for *Magic Tree*, f = mark scored for *Fix Me*, g = the total mark of *Magic Tree*, and h = the total mark of *Fix Me*
I can differentiate colours	d = mark scored for *Ball Game*, f = mark scored for *Building Blocks* (for colour recognition), g = the total mark of *Ball Game*, and h = the total mark of *Building Blocks* (for colour recognition)
I can identify shapes	d = mark scored for *Keep the Toys*, f = mark scored for *Building Blocks* (for shape recognition), g = the total mark of *Keep the Toys*, and h = the total mark of *Building Blocks* (for shape recognition)
I know about numbers	d = mark scored for *Open Sesame*, and g = the total mark of *Open Sesame*, where f = h = 0
I can count things	d = mark scored for *Counting Game*, f = mark scored for *Let's Count*, g = the total mark of *Counting Game*, and h = the total mark of *Let's Count*

Table 5.1 summarises the details of the grading scheme for cognitive skill performance. For example, if a child scored 3 out of 3 in *Magic Tree* assessment and 2 out of 2 in *Fix Me* assessment, the final score, j = [(3+2)/(3+2)] x 100% = 100%. Five stars (*Excellent Performance*) will be displayed on the row of "I can work with body parts". Similarly, the rest of the cognitive skills ("I can identify shapes" and etc.) are calculated using the equation (5.2). "I know about numbers" involves only one test, which is *Open Sesame*, therefore variables f and h are set to 0.



(a) Report card for boy

(b) Report card for girl

Figure 5.13: The report card for psychomotor skills performance

Figure 5.13 shows the testing for system output on the children's performance in psychomotor skills. The score collected from the assessments will be added and converted to 100%. The conversion is done using the equation (5.2). Table 5.2 summarises the details of the grading scheme for psychomotor skill performance. “I can push a thing” and “I can pull a thing” involve only one test, which is *Push* and *Pull*, therefore variables f and h are set to 0.

Table 5.2: Details of grading scheme for psychomotor skill performance

I can catch a ball	d = mark scored for *Catch* (*Virtual Game Assessment*), f = mark scored for *Ball Catching* (*Physical Game Assessment*), g = the total mark of *Catch*, and h = the total mark of *Ball Catching*
I can throw a ball	d = mark scored for *Throw* (*Virtual Game Assessment*), f = mark scored for *Ball Throwing*(*Physical Game Assessment*), g = the total mark of *Throw*, and h = the total mark of *Ball Throwing*
I can push a thing	d = mark scored for *Push*, and g = the total mark of *Push*, where f = h = 0

Table 5.2, continued

I can pull a thing	d = mark scored for *Pull*, and g = the total mark of *Pull*, where f = h = 0
I can hop	d = mark scored for *Hop* (*Virtual Game Assessment*), f = mark scored for *Hopping* (*Physical Game Assessment*), g = the total mark of *Hop*, and h = the total mark of *Hopping*
I can jump	d = mark scored for *Jump* (*Virtual Game Assessment*), f = mark scored for *Jumping* (*Physical Game Assessment*), g = the total mark of *Jump*, and h = the total mark of *Jumping*
I can kick	d = mark scored for *Kick* (*Virtual Game Assessment*), f = mark scored for *Ball Passing/Kicking*(*Physical Game Assessment*), g = the total mark of *Kick*, and h = the total mark of *Ball Passing/Kicking*
I can run	d = mark scored for *Run* (*Virtual Game Assessment*), f = mark scored for *Running*(*Physical Game Assessment*), g = the total mark of *Run*, and h = the total mark of *Running*
I can stand on one leg	d = mark scored for *Balance* (*Virtual Game Assessment*), f = mark scored for *One Leg Stand*(*Physical Game Assessment*), g = the total mark of *Balance*, and h = the total mark of *One Leg Stand*

5.3 Results and Analysis

This section begins with the evaluation of the proposed framework. For system evaluation, an intervention program was conducted. After the intervention program was completed, all the enrolled preschool children proceeded to evaluations of their learning performances. As described in Chapter 3, the control group sat for *Physical Game Assessment* whereas the experimental group took both the *Physical Game Assessment* and *Virtual Game Assessment* (see Figure 3.5). The results were then analysed for three areas of development, language and communication, cognitive skills and psychomotor skills. Multiple comparisons were made among group (control group versus experimental group), gender, and level of performance (*Excellent*, *Average*, and *Low Performance*) to evaluate the effect of the intervention program on learning performance. Correlations between language and communication, cognitive skills and psychomotor skills were studied as well.

Correlational analysis was used to investigate the relationship between language and communication, cognitive, and psychomotor skills. Besides, the analysis can also show the degree of correlation if any of the aforementioned areas of children development is associated. Multiple regression analysis was run to find out the predictor which account for the significant correlation. These two analyses can help to provide insight into how language and communication, cognitive, and psychomotor skills are interrelated.

5.3.1 Evaluation of framework

The evaluation of proposed framework for preschool children's learning was based on the checklist provided by four-dimensional framework. This checklist helps to determine how learning takes place by considering the relationship between games and contexts of use for pedagogic purposes (De Freitas & Oliver, 2006). Table 5.3 summarises the evaluation by four dimensions: context, learner specification, pedagogic considerations, and mode of representation.

Table 5.3: Evaluation of proposed framework

Checklist	Context
What is the context for learning?	Preschool.
Does the context affect learning?	Classroom based.
How can links be made between context and practice?	Gesture- and voice-based interactions with the software. The software runs on Xbox Kinect video console.

Table 5.3, continued

Checklist	Learner specification
Who is learner?	Preschool children at age four.
What is their background and learning history?	The learning system focuses on preschool learning but can be used by other ages (e.g. 4-7 year olds) and in informal setting.
What are the learning styles/preferences?	Individual and/or group learning.
How can the learner or learner group be best supported?	The learning system (*myKinderLand*) supports the children to learn and play singly and in groups.

Checklist	Pedagogic considerations
Which pedagogic models and approaches are being used?	*myKinderLand* uses instructional approach, scaffolding, imitation, trial-and-error approach, and also supports experiential learning cycle.
Which pedagogic models and approaches might be the most effective?	Instructional learning with scaffolding and imitation approach is recommended for preschool learning. Trial-and-error approach embedded with gesture- and voice-based interaction is suggested for practical session. Present of teacher is essential for discipline and learning progress monitoring.
What are the curricula objectives	Develop language and communication, cognitive, and psychomotor skills of preschool children.
What are the learning outcomes?	Improve language and communication, cognitive, and psychomotor skills of preschool children.
What are the learning activities?	The children learn language and communication, cognitive, and psychomotor skills through the learning modules (*Learn with fun, Move Your Body*, and *Mind Games*).
How can the learning activities and outcomes be achieved through specially developed software?	The game-based learning activities engaged the children with learning. The instructional approach together with scaffolding, imitation, trial-and-error, and feedback assisted the children in learning and improved their mistake in a direct manner.
How can evaluation be used to reinforce learning outcomes?	Teacher can understand and monitor the children's learning progress based on the evaluation (Q & A).

Table 5.3, continued

Checklist	Mode of representation (tools of use)
Which software tools or content would best support the learning activities?	*myKinderLand* is well supported by Xbox Kinect, which children can use voice and body movement to interact with the system.
What level of fidelity needs to be used to support learning activities and outcomes?	The learning system uses high fidelity based upon the use of 3D animated characters and avatars.
What level of immersion is needed to support learning outcomes?	Simulation and instant response from the animated avatar gave direct feedback to the children for their action. This helps to praise the children immediately if they did well or show them the right response/answer if they made mistake.
How can links be made between the world of the game/simulation and reflection upon learning?	The connection between game and reflection upon learning processes can observed through classroom game and also examined via classroom-based evaluation (*Physical Game Assessment*).

5.3.2 Teachers' Feedback

After the completion of intervention program, 32 participated teachers were invited to participate in a feedback survey on their acceptance of the proposed system for preschool learning. They were also interviewed for the impact of this work on children learning and classroom practices.

5.3.2.1 Feedback on Learning Modules

Six questions were used to collect feedback from the teachers after using the learning modules (see Appendix C). Overall, approximately 94% of the participants strongly agreed that the modules were well organised and easy to use (see Q1 in Figure 5.14). In addition, nearly 94% of the participants were pleased with using the menu navigation feature when searching the learning material (refer Q2). All the participants thought it was easy to terminate the system (refer Q3). The majority of the participants (94%)

agreed that the learning modules were helpful for their teaching (63% strongly agree and 31% agree, see Q4), the use of instruction, visual aids and demonstration (scaffolding) and feedback were useful (47% strongly agree and 47% agree, see Q5), and would use it for their teaching (47% strongly agree and 47% agree, see Q6).

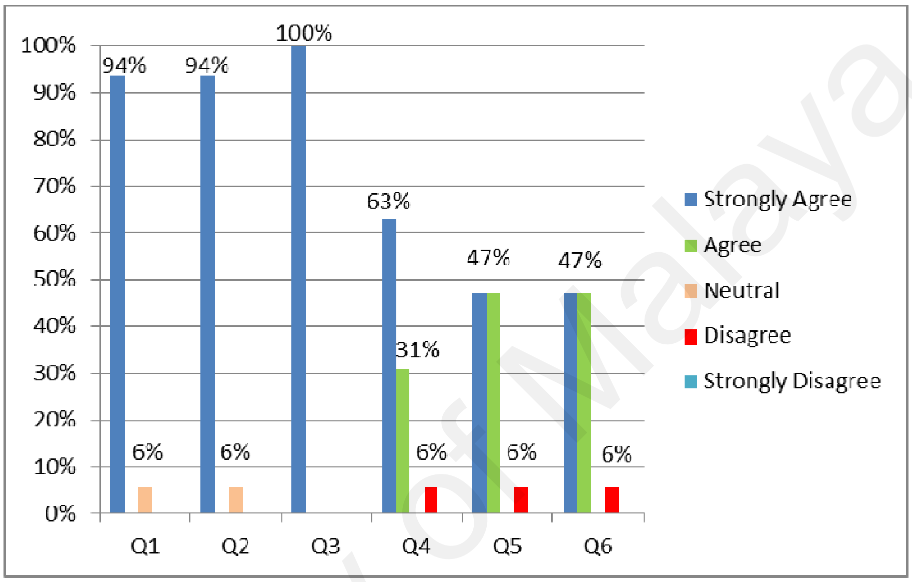


Figure 5.14: Teachers' feedback on Learning Modules

5.3.2.2 Feedback on Assessment Modules

Eleven questions were used to collect feedback from the teachers after using the assessment modules (see Appendix C). Overall, the *Physical Game Assessment* was highly supported by the participants. Approximately 94% of the participants (88% strongly agree and 6% agree) agreed that this assessment module was well organised and easy to use (see Q7 in Figure 5.15). All the participants agreed that the marking scheme was simple and useful (refer Q8). Nearly 94% of the participants (81% strongly agree and 13% agree) felt it was easy to terminate the system (refer Q9). All of them agreed that the *Physical Game Assessment* helped them to understand the children's progress better (refer Q10). Over 90% of the participants would use it for children's assessment (refer Q11).

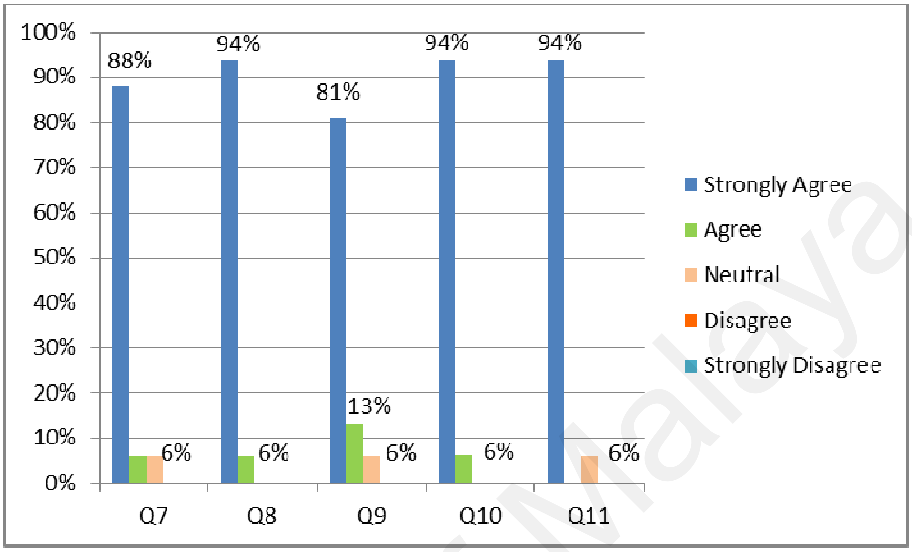


Figure 5.15: Teachers' feedback on *Physical Game Assessment*

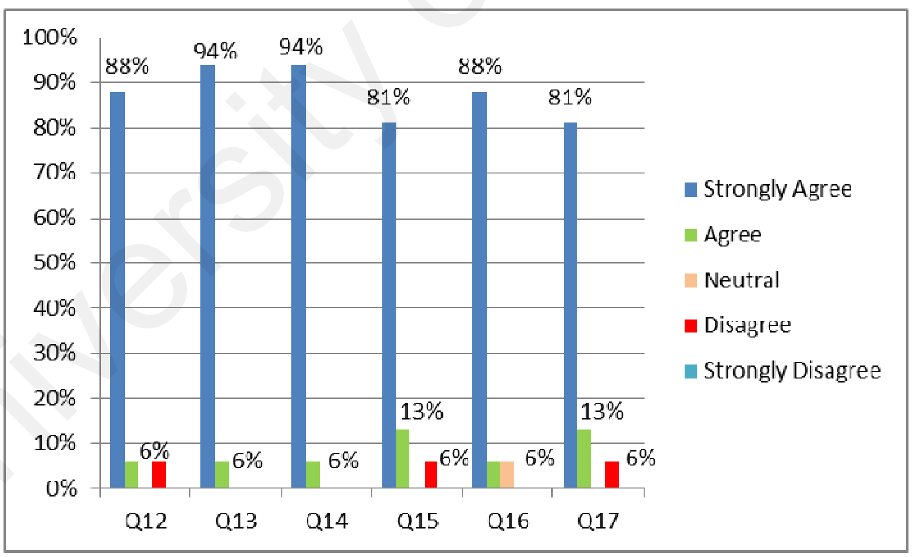


Figure 5.16: Teachers' feedback on *Virtual Game Assessment*

Approximately 94% of the participants (88% strongly agree and 6% agree) agreed that the *Virtual Game Assessment* was well organised and easy to use (see Q12 in Figure 5.16). All the participants favoured the ease of use of the menu when selecting the assessment (refer Q13) and terminating the system (refer Q14). Approximately 94% of the participants (81% strongly agree and 13% agree) agreed that it helped them to evaluate the children more easily (refer Q15). Nearly 94% of the participants (88% strongly agree and 6% agree) liked the report card (refer Q16). Over 90% of the participants (81% strongly agree and 13% agree) would use it for the children's assessment (refer Q17).

5.3.2.3 Summary of Finding from the Interview with Teachers

Overall, majority of the teachers' perspective on using GBL in classroom practice was positive. They felt glad and comfortable starting from system design till children's evaluation. They noticed there were great changes in their role. First, they became the advisor to the project team. They verified the learning content and ensured the learning objectives were achieved. Besides, they also checked whether the developed game matched with the knowledge level of preschool children or not. Secondly, they became facilitators during the learning. They were no longer doing the entire teaching job and talking in the class. They have more time to observe the children and assist those who need additional attention and guidance. Lastly, they acted as evaluators at the end of the program. They were happy to notice that the children could learn and apply what they have been taught:

> "*I noticed that they have better hand-eye coordination when they are doing exercise, playing with ball, and also building blocks."*- Teacher A
>
> "*They remember all those words!*"- Teacher B
>
> "*Their response is very fast. I mean they know the answer and they are happy to get it right.*"- Teacher C

"*Now we have more things to talk about and have more fun in the class.*"

- Teacher D

High engagement of children with the GBL system make the teachers felt enthusiastic about the impact of GBL in children learning and their practice. Besides, strong acceptance and adaptability of children with gaming technology also convinced them to integrate GBL with curricula. They observed how the children learned to interact with the system, how they improved, and get used to it. For example, when the teacher navigate the system to choose an exercise, children would said, "*Teacher, hold your hand there.*" or "*Hold a bit longer.*"

However, two teachers (6%) disagreed on the use of GBL in their teaching. They prefer the children to have real interaction and get closer with natural environment. They felt hardly to accept teaching with games. Besides, they have doubt on the effectiveness of GBL in teaching preschool children. They preferred physical assessment methods rather than the VLE approach as their assessment tool. Nevertheless, they had no issue with the *Physical Game Assessment*. Lack of technological knowledge and experience in handling the gaming console were the main reasons why they felt reluctance to use GBL in their practice.

5.3.3 Observation on Children Behaviour

The behaviour of all the participants while interacting with the learning system was observed and recorded using field notes throughout the intervention program. Overall, the children showed high engagement with the learning system. 95.12% (39) of the children attended all the sessions and the remaining 4.88% (2 children) missed one session due to absent. The intervention program was conducted for 4 weeks, 5 days per week, and each session consisted of 40 minutes. During the first three sessions, 73.17% (30) of the children felt excited whereas the remaining children were shy and required teacher assistance to follow the lessons. After getting familiar with the learning system, they showed up voluntarily and started to engage with the lessons. They laughed and talked about their experience with the learning system within and after the lesson:

"*When I move, it moves. So funny.*"- Child A

"*I like the smiley face.*"- Child B

" *I am good. He (the avatar) always says well done.*"- Child C

"*I want to play more.*"- Child D

The learning modules consisted of *Learn with Fun, Move Your Body*, and *Mind Games*. Overall, most of the children have no issue on using the learning modules to learn. They were fully engage with the modules and completed their learning within each session. For assessment modules, the children used two to three sessions to complete all the assessments. All of them were having fun when interacting with the system. They did not realised they were doing assessment. They thought they were playing game:

"*Run, run faster!*"- Child E

"*Hahaha..., I get it right!.*"- Child F

" *I get all the question correct!.*"- Child G

"*I catch all the fish! I win.*"- Child H

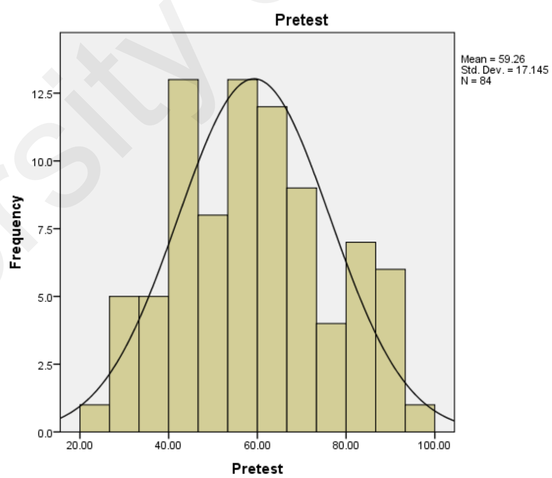
5.3.4 Analysis of Children's Performance

5.3.4.1 Analysis of Pre-test

A total of 84 preschool children took the pre-test. The sample of data with sample size, n = 84 (mean, m = 59.26, standard deviation (SD), σ = 17.145) is normally distributed (bell-shaped) and fairly symmetrical (skewness < 0.5) with lighter tail (kurtosis =-0.578) as depicted in Figure 5.17 (a) and (b). The pre-test performance was further analysed by gender (see Figure 5.18). Overall, girls (median=61.82) have higher scores compared to boys (median=54.77).

	N	Variance	Std. Deviation	Skewness		Kurtosis	
		Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Valid	84	293.950	17.145	.245	.263	-.578	.520
Missing	0						

(a) Descriptive statistics



(b) Histogram

Figure 5.17: Analysis for pre-test performance

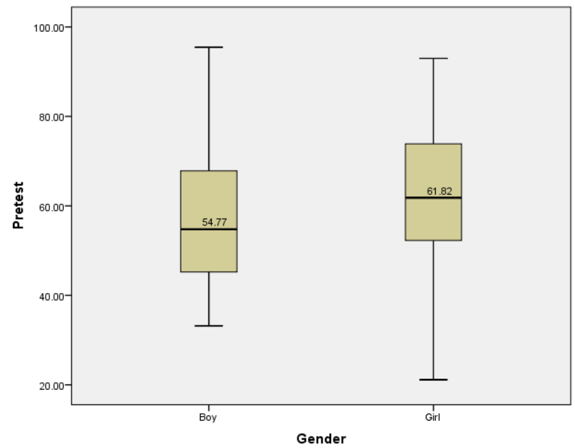


Figure 5.18: Box plot for pre-test performance by gender

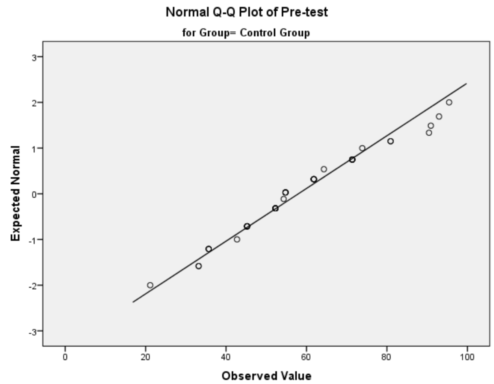
Before the intervention program was executed, 84 preschool children were graded based on their level of performance (*Excellent Performance*: 80≤ score ≤100, *Average Performance*: 50≤ score ≤79 and *Low Performance*: 0≤ score ≤49). The preschool children in each level of performance were then randomly divided into two groups, namely control and experimental. A normality test (Shapiro-Wilk Test) for each group was conducted to ensure the sample is normally distributed. As the *Sig.* (significant) value of the Shapiro-Wilk Test was greater than 0.05, the collected data was normal (see Table 5.4). The Q-Q plots for control group and experimental group based on the pre-test results are depicted in Figure 5.19. The data points for both plots are close to the diagonal line, which shows that the random assignment of preschool children to control group and experimental group followed a normal distribution.

Table 5.4: Normality test for group assignment

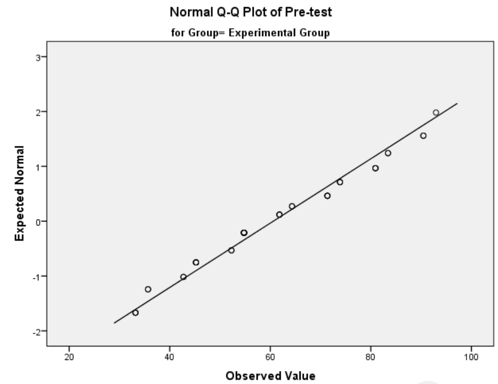
Tests of Normality

Group		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Pre-test	Control Group	.132	43	.059	.967	43	.242
	Experimental Group	.146	41	.028	.957	41	.127

a. Lilliefors Significance Correction



(a) Histogram for control group



(b) Histogram for experimental group

Figure 5.19: Analysis of preschool children's performance by group

5.3.4.2 Analysis of Physical Game Assessment

There are two types of post-test (*Physical Game Assessment* and *Virtual Game Assessment)* designed for this study. *Physical Game Assessment* consists of seven assessments: *Building Blocks*, *Counting Game, Card Game*, *Puzzle*, *Question and Answer* (*Q & A*) *Game*, *Ball Game*, and *Leg Game*. *Building Blocks* and *Counting Game* are grouped as cognitive skills assessment; *Card Game*, *Puzzle*, and *Q & A Game* are classified as language and communication skills assessments whereas psychomotor skills assessment comprises *Ball Game* and *Leg Game*.

The analysis of preschool children's performance started with the comparison of their overall performance in pre-test and post-test. The results were further studied through the dimensions of group, gender, and level of performance. The collected data (pre-test and post-test) were analysed through analysis of variance (ANOVA), analysis of covariance (ANCOVA), multivariate analysis of variance (MANOVA), pairwise comparison, correlational, and multiple regression analysis. The significance level was set at 0.05. ANOVA examines the differences in the group means whereas ANCOVA looks for differences in adjusted means (i.e. pre-test). The purpose of using the pre-test result as a covariate in ANCOVA with a pretest-posttest design is to reduce the error variance (Dimitrov & Rumrill Jr, 2003).

Analysis of Overall Performance

A three-way ANOVA test was conducted to examine the preschool children's performance by group, gender, and level of performance. According to Table 5.5, there was a statistically significant differences between groups ($F(1,72)=40.70,\ p<0.01$) and level of performance ($F(2,72)=3.97,\ p<0.05$). No significant differences were found to exist neither between genders nor for the interaction effect of group, gender, and level of performance. A profile plot was used to illustrate the differences in performance between control group and experimental group (see Figure 5.20). The mean for both groups was increased but the experimental group ($m_{pre\text{-}test}$= 60.52 and $m_{post\text{-}test}$= 89.41) demonstrated greater improvement than the control group ($m_{pre\text{-}test}$= 58.29 and $m_{post\text{-}test}$= 73.00).

Table 5.5: Three-way ANOVA test for *Physical Game Assessment*

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	6674.278[a]	11	606.753	6.406	.000	.495
Intercept	406718.531	1	406718.531	4294.205	.000	.984
Group	3855.038	1	3855.038	40.702	.000	.361
Gender	.013	1	.013	.000	.991	.000
Level	751.789	2	375.894	3.969	.023	.099
Group * Gender	52.763	1	52.763	.557	.458	.008
Group * Level	1.899	2	.950	.010	.990	.000
Gender * Level	211.985	2	105.993	1.119	.332	.030
Group * Gender* Level	146.655	2	73.327	.774	.465	.021
Error	6819. 361	72	94.713			
Total	564440.926	84				
Corrected Total	13493.639	83				

a. R Squared = .495 (Adjusted R Squared = .417)

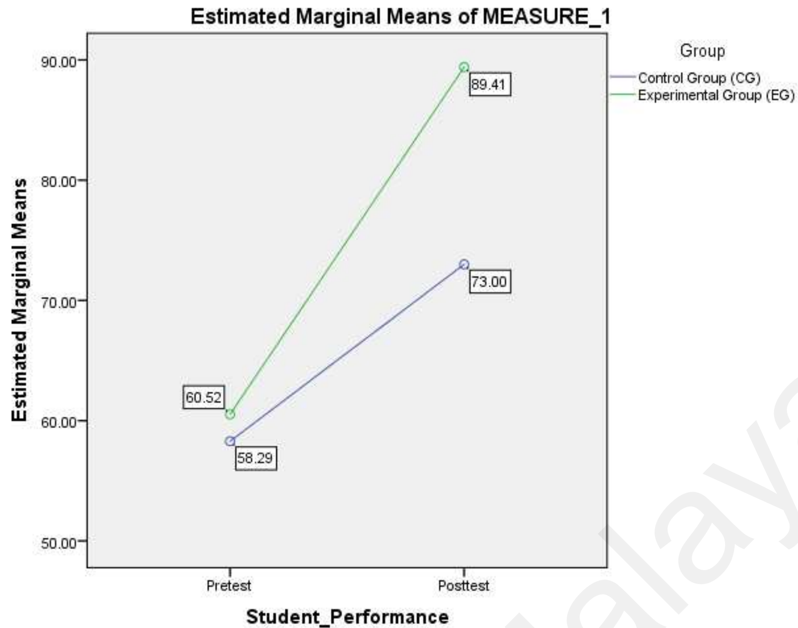


Figure 5.20: Profile plot for the pre-test and post-test performance between groups

Analysis of Performance by Group and Level of Performance

A one-way ANCOVA test was run to examine the interaction between groups for each level of performance. The independent variables were group (control, experimental group) and level of performance (*Excellent*, *Average*, *Low*). The dependent variable was the preschool children's score in *Physical Game Assessment* and the covariate was their pre-test score (see Table 5.6). The ANCOVA was significant for all the three levels of performance: *Excellent* ($F(1,11)=16.56,\ p<0.01$), *Average* ($F(1,42)=32.60,\ p<0.01$), and *Low performance*($F(1,22)=13.33,\ p<0.01$).

Table 5.6: One-way ANCOVA test for different levels of performance

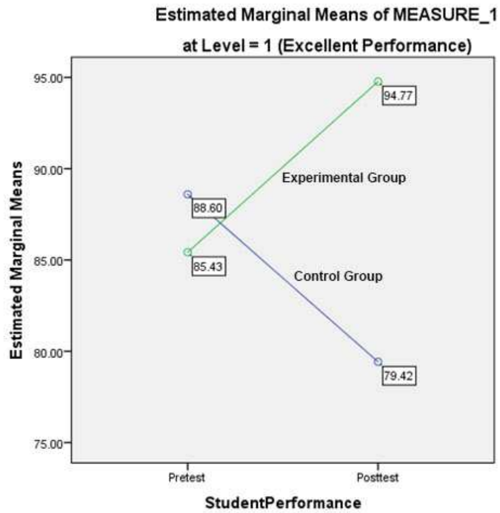
Level	Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Excellent	Corrected Model	870.459[a]	2	435.230	8.283	.006	.601
	Intercept	127.724	1	127.724	2.431	.147	.181
	Pretest	62.770	1	62.770	1.195	.298	.098
	Group	869.930	1	869.930	16.557	.002	.601
	Level	.000	0				.000
	Group * Level	.000	0				.000
	Error	577. 968	11	52.543			
	Total	110344.959	14				
	Corrected Total	1448.427	13				
Average	Corrected Model	3167.568[a]	2	1583.784	17.559	.000	.455
	Intercept	3263.784	1	3263.784	36.185	.000	.463
	Pretest	119.122	1	119.122	1.321	.257	.030
	Group	2940.391	1	2940.391	32.600	.000	.437
	Level	.000	0				.000
	Group * Level	.000	0				.000
	Error	3788.233	42	90.196			
	Total	298340.233	45				
	Corrected Total	6955.801	43				
Low	Corrected Model	1620.450[a]	2	810.225	7.162	.004	.394
	Intercept	3029.447	1	3029.447	26.779	.000	.549
	Pretest	141.074	1	141.074	1.247	.276	.054
	Group	1508.163	1	1508.163	13.332	.001	.377
	Level	.000	0				.000
	Group * Level	.000	0				.000
	Error	2488. 765	22	113.126			
	Total	155755.736	25				
	Corrected Total	4109.215	24				

a. R Squared = .601 (Adjusted R Squared = .528)
b. R Squared = .455 (Adjusted R Squared = .429)
c. R Squared = .394 (Adjusted R Squared = .339)

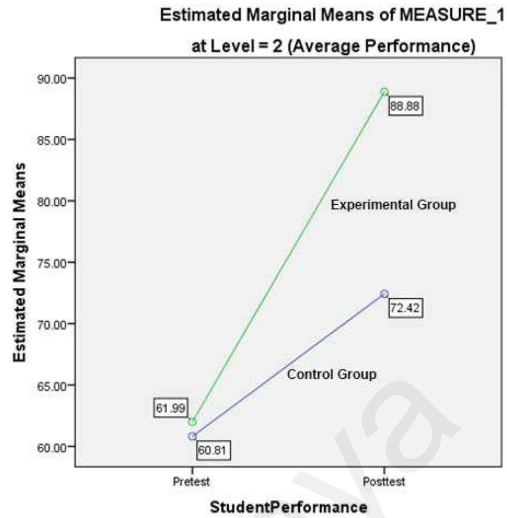
Table 5.7: Pairwise comparison for three levels of performance by group

Level	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence interval for Difference [b]	
						Lower Bound	Upper Bound
Excellent	CG	EG	-16.656*	4.093	.002	-25.665	-7.646
	EG	CG	-16.656*	4.093	.002	7.646	25.665
Average	CG	EG	-16.218*	2.840	.000	-21.950	-10.485
	EG	CG	-16.218*	2.840	.000	10.485	21.950
Low	CG	EG	-15.656*	4.288	.001	-24.548	-6.763
	EG	CG	-15.656*	4.288	.001	6.763	24.548

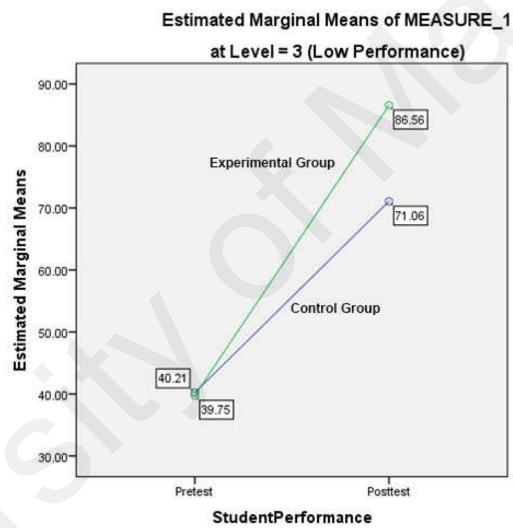
CG = Control Group, EG = Experimental Group
Based on estimated marginal means
*. The mean difference is significant at the.05 level.
b. Adjustment for multiple comparisons: Bonferroni.



(a) *Excellent* performance



(b) *Average* performance



(c) *Low* performance

Figure 5.21: Profile plot for three levels of performance by group

Follow-up tests were carried out to evaluate pairwise differences among the adjusted means for control group and experimental group using Bonferroni adjustment. Table 5.7 indicates that the preschool children in experimental group with *Excellent* ($m=16.66, p<0.05$), *Average* ($m=16.22, p<0.05$), and *Low performance* ($m=15.66, p<0.05$) outperformed the preschool children in the control group. Figure 5.21 (a) illustrated the comparison between the control group and experimental group for *Excellent* while *Average* and *Low performance* are shown in Figures 5.21 (b) and (c), respectively.

Analysis of Performance by Areas of Development

Table 5.8: Multivariate tests for the analysis in area of development between group and level

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Area Of Development	Pillai's Trace	.948	701.575[b]	2.000	77.000	.000	.948
	Wilks's Lambda	.052	701.575[b]	2.000	77.000	.000	.948
	Hotelling's Trace	18.223	701.575[b]	2.000	77.000	.000	.948
	Roy's Largest Root	18.223	701.575[b]	2.000	77.000	.000	.948
Area Of Development * Group	Pillai's Trace	.600	57.663[b]	2.000	77.000	.000	.600
	Wilks's Lambda	.400	57.663[b]	2.000	77.000	.000	.600
	Hotelling's Trace	1.498	57.663[b]	2.000	77.000	.000	.600
	Roy's Largest Root	1.498	57.663[b]	2.000	77.000	.000	.600
Area Of Development * Level	Pillai's Trace	.265	5.945	4.000	156.000	.000	.132
	Wilks's Lambda	.736	6.387[b]	4.000	154.000	.000	.142
	Hotelling's Trace	.359	6.821	4.000	152.000	.000	.152
	Roy's Largest Root	.358	13.971[c]	2.000	78.000	.000	.264
Area Of Development * Group * Level	Pillai's Trace	.002	.047	4.000	156.000	.996	.001
	Wilks's Lambda	.998	.046[b]	4.000	154.000	.996	.001
	Hotelling's Trace	.002	.046	4.000	152.000	.996	.001
	Roy's Largest Root	.002	.094[c]	2.000	78.000	.911	.002

b. Exact statistic
c. The statistic is an upper bound on F that yields a lower bound on the significance level.

The association between groups and level of performance (independent variables) by areas of development, which are language and communication, cognitive and psychomotor skills (dependent variables), was examined. Multivariate tests found that there were statistically significant differences for the main effect of area of development (*F(2,77)=701.58, p=0.000, Wilks'Λ=0.052*), interaction between area of development and group (*F(2,77)=57.66, p=0.000,Wilks'Λ=0.4*) as well as the area of development and level of performance (*F(4,154)=6.39, p=0.000,Wilks'Λ=0.736*) (see Table 5.8).

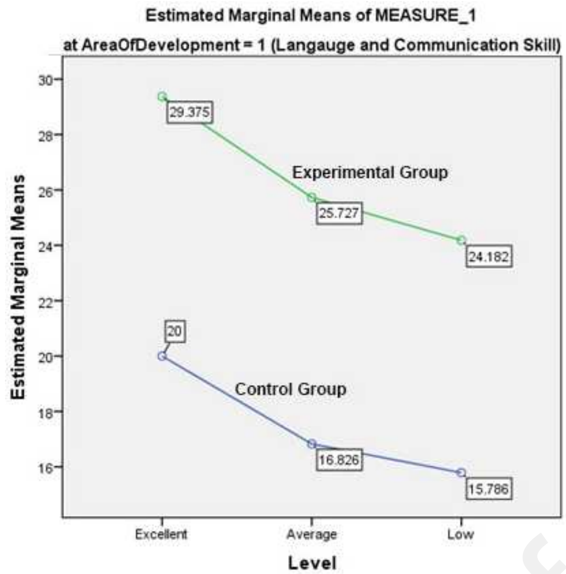
Table 5.9: Two-way MANOVA test for three areas of development

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	P_Language	1940.023[a]	5	388.05	50.819	.000	.765
	P_Cognitive	445.069[b]	5	89.014	5.795	.000	.271
	P_Psychomotor	11.350[c]	5	2.270	.879	.005	.053
Intercept	P_Language	32041.511	1	32041.511	4196.616	.000	.982
	P_Cognitive	26482.445	1	26482.445	1723.990	.000	.957
	P_Psychomotor	4178.987	1	4178.987	1617.328	.000	.954
Group	P_Language	1310.301	1	1310.301	171.616	.000	.688
	P_Cognitive	333.394	1	333.394	21.704	.000	.218
	P_Psychomotor	4.951	1	4.951	1.916	.170	.024
Level	P_Language	198.065	2	99.033	12.971	.000	.250
	P_Cognitive	7.484	2	3.742	.244	.784	.006
	P_Psychomotor	5.059	2	2.530	.979	.380	.024
Group * Level	P_Language	2.235	2	1.118	.146	.864	.004
	P_Cognitive	8.844	2	4.422	.288	.751	.007
	P_Psychomotor	2.132	2	1.066	.412	.663	.010
Error	P_Language	595.536	78	7.635			
	P_Cognitive	1198.169	78	15.361			
	P_Psychomotor	201.543	78	2.584			
Total	P_Language	40893.000	84				
	P_Cognitive	34924.000	84				
	P_Psychomotor	5637.000	84				
Corrected Total	P_Language	2535.560	83				
	P_Cognitive	1643.238	83				
	P_Psychomotor	212.893	83				

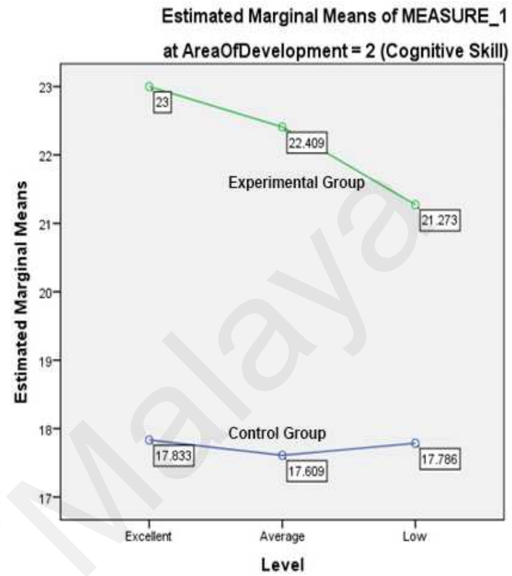
a. R Squared = .765 (Adjusted R Squared = .750)
b. R Squared = .271 (Adjusted R Squared = .224)
c. R Squared = .053 (Adjusted R Squared = .007)

Follow up testing further analysed the differences in performance in three areas of development by group and level of performance (see Table 5.9). The group has a statistically significant effect on language and communication skill ($F(1,78)=171.62, p<0.001, \eta^2=0.69$) and cognitive skill performance ($F(1,78)=21.70, p<0.001, \eta^2=0.22$). In addition, level of performance only affects language and communication performance ($F(2,78)=12.97, p<0.001, \eta^2=0.25$).

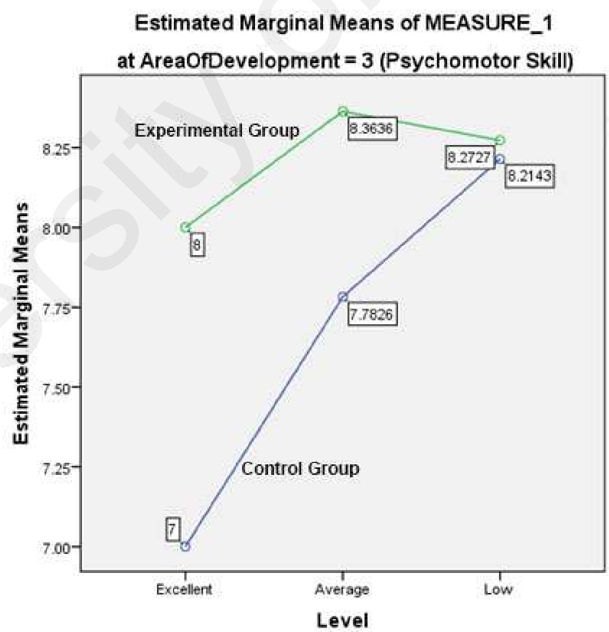
Figures 5.22 (a), (b), and (c) are used to illustrate the differences in performance between groups and level of performance in the area of development for language and communication, cognitive, and psychomotor skills, respectively. Although the effect of group was not significant for psychomotor skills, the children in the experimental group for all levels of performance outperformed the control group in the aforementioned area of development.



(a) Language and communication skill



(b) Cognitive skill



(c) Psychomotor skill

Figure 5.22: Profile plot for three different areas of development by group and level of performance

Analysis of Performance by Assessments

MANOVA test was conducted to further examine the differences of performance in each assessment by group and level of performance (see Table 5.10). The procedure of Bonferroni was used to control for Type I error for the main effect of group and level of performance by each assessment.

There were significant differences between groups in *Building Blocks* ($F(1,78)=13.94, p<0.001, \eta^2=0.15$), *Counting Game* ($F(1,78)=21.67, p<0.001, \eta^2=0.22$), *Card Game* ($F(1,78)=46.00, p<0.001, \eta^2=0.37$), *Puzzle* ($F(1,78)=14.67, p<0.001, \eta^2=0.16$), and *Q & A Game* ($F(1,78)=60.95, p<0.001, \eta^2=0.44$) whereas the differences caused by level of performance only occurred in *Card Game* ($F(2,78)=10.985, p<0.001, \eta^2=0.22$). *Card Game*, *Puzzle*, and *Question and Answer* (*Q & A*) *Game* are the assessments for language and communication skills. *Building Blocks* and *Counting Game* are used to evaluate the cognitive skill of preschool children whereas *Ball Game* and *Leg Game* measure psychomotor skill performance. Follow-up tests using Bonferroni adjustment were carried out for *Building Blocks*, *Counting Game*, *Card Game*, *Puzzle*, and *Q & A Game*, *Ball Game*, and *Leg Game* to examine where the differences lay.

Table 5.10: Two-way MANOVA test for *Building Blocks, Counting Game, Card Game and Puzzle and Q & A Game*

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	Block	236.124[a]	5	47.225	3.793	.004	.196
	Counting	47.128[b]	5	9.246	7.896	.000	.336
	Card Game	539.487[c]	5	107.897	16.550	.000	.515
	Puzzle	39.860[d]	5	7.972	7.256	.000	.317
	QnA	273.255[e]	5	54.651	15.076	.000	.491
	Ball Game	.965[f]	5	.193	1.360	.249	.080
	Leg Game	11.350[g]	5	2.270	.879	.500	.053

Table 5.10, continued

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	Block	16250.209	1	16250.209	1305.155	.000	.944
	Counting	1243.125	1	1243.125	1041.389	.000	.930
	Card Game	6000.901	1	6000.901	920.469	.000	.922
	Puzzle	1346.818	1	1346.818	1225.812	.000	.940
	QnA	4203.826	1	4203.826	1159.696	.000	.937
	Ball Game	241.446	1	241.446	1701.159	.000	.956
	Leg Game	4178.987	1	4178.987	1617.328	.000	.954
Group	Block	173.526	1	173.526	13.937	.000	.152
	Counting	25.869	1	25.869	21.671	.000	.217
	Card Game	299.932	1	299.932	46.006	.000	.371
	Puzzle	16.122	1	16.122	14.674	.000	.158
	QnA	220.948	1	220.948	60.952	.000	.439
	Ball Game	.250	1	.250	1.764	.188	.022
	Leg Game	4.951	1	4.951	1.916	.170	.024
Level	Block	.271	2	.136	.011	.989	.000
	Counting	4.994	2	2.497	2.092	.130	.051
	Card Game	143.228	2	71.614	10.985	.000	.220
	Puzzle	4.433	2	2.216	2.017	.140	.049
	QnA	3.643	2	1.821	.502	.607	.013
	Ball Game	.336	2	.168	1.185	.311	.029
	Leg Game	5.059	2	2.530	.979	.380	.024
Group * Level	Block	24.042	2	12.021	.965	.385	.024
	Counting	3.844	2	1.922	1.610	.206	.040
	Card Game	3.947	2	1.974	.303	.740	.008
	Puzzle	4.433	2	2.216	2.017	.140	.049
	QnA	1.971	2	.985	.272	.763	.007
	Ball Game	.096	2	.048	.338	.714	.009
	Leg Game	2.132	2	1.066	.412	.663	.010
Error	Block	971.161	78	12.451			
	Counting	93.110	78	1.194			
	Card Game	508.513	78	6.519			
	Puzzle	85.700	78	1.099			
	QnA	282.745	78	3.625			
	Ball Game	11.071	78	.142			
	Leg Game	201.543	78	2.584			
Total	Block	21762.000	84				
	Counting	166.000	84				
	Card Game	7852.000	84				
	Puzzle	1729.000	84				
	QnA	5932.000	84				
	Ball Game	313.000	84				
	Leg Game	5637.000	84				
Corrected Total	Block	1207.286	83				
	Counting	140.238	83				
	Card Game	1048.000	83				
	Puzzle	125.560	83				
	QnA	556.000	83				
	Ball Game	12.036	83				
	Leg Game	212.893	83				

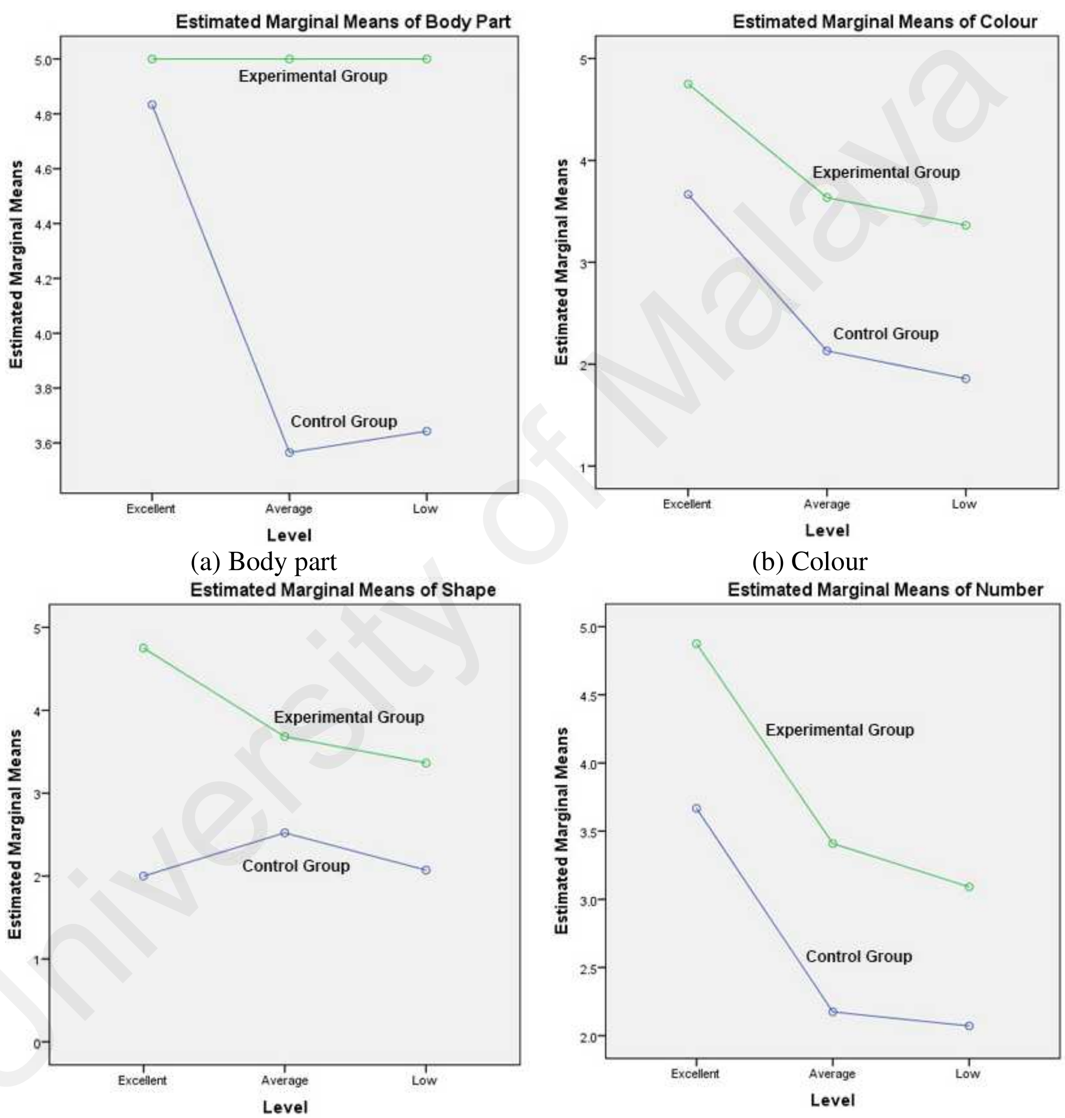
a. R Squared = .196 (Adjusted R Squared = .144)
b. R Squared = .336 (Adjusted R Squared = .293)
c. R Squared = .515 (Adjusted R Squared = .484)
d. R Squared = .317 (Adjusted R Squared = .274)
e. R Squared = .491 (Adjusted R Squared = .459)
f. R Squared = .080 (Adjusted R Squared = .021)
g. R Squared = .053 (Adjusted R Squared = - .007)

Table 5.11: Two-way MANOVA test for *Body Part, Colour, Shape,* and *Number*

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	Body Part	39.860[a]	5	7.972	7.256	.000	.317
	Colour	73.207[b]	5	14.641	10.497	.000	.402
	Shape	59.407[c]	5	11.881	9.132	.000	.369
	Number	62.224[d]	5	12.445	9.643	.000	.382
Intercept	Body Part	1346.818	1	1346.818	1225.812	.000	.940
	Colour	693.496	1	693.496	497.209	.000	.864
	Shape	622.000	1	622.000	478.672	.000	.860
	Number	685.141	1	685.141	530.861	.000	.872
Group	Body Part	16.122	1	16.122	14.674	.000	.158
	Colour	30.897	1	30.897	22.152	.000	.221
	Shape	49.847	1	49.847	38.311	.000	.329
	Number	22.088	1	22.088	17.114	.000	.180
Level	Body Part	4.433	2	2.216	2.017	.140	.049
	Colour	24.340	2	12.170	8.725	.000	.183
	Shape	4.269	2	2.135	1.641	.200	.040
	Number	28.365	2	14.182	10.989	.000	.220
Group * Level	Body Part	4.433	2	2.216	2.017	.140	.049
	Colour	.512	2	.256	.184	.833	.005
	Shape	6.890	2	3.445	2.648	.077	.064
	Number	.192	2	.096	.074	.928	.002
Error	Body Part	85.700	78	1.099			
	Colour	108.793	78	1.395			
	Shape	101.486	78	1.301			
	Number	100.669	78	1.291			
Total	Body Part	1729.000	84				
	Colour	938.000	84				
	Shape	935.000	84				
	Number	901.000	84				
Corrected Total	Body Part	125.560	83				
	Colour	182.000	83				
	Shape	160.893	83				
	Number	162.893	83				

a. R Squared = .317 (Adjusted R Squared = .274)
b. R Squared = .402 (Adjusted R Squared = .364)
c. R Squared = .369 (Adjusted R Squared = .329)
d. R Squared = .382 (Adjusted R Squared = .342)

The effect of group was significant for all the word categories: body part ($F(1,78)=14.67,\ p<0.001,\ \eta^2=0.16$), colour ($F(1,78)=22.15,\ p<0.001,\ \eta^2=0.22$), shape ($F(1,78)=38.31,\ p<0.001,\ \eta^2=0.33$), and number ($F(1,78)=17.11,\ p<0.001,\ \eta^2=0.18$) (see Table 5.11). The effect of level of performance was only significant for the word recognition of colour ($F(2,78)=8.73,\ p<0.001,\ \eta^2=0.18$) and number ($F(2,78)=10.99,\ p<0.001,\ \eta^2=0.22$). However, the interaction effect between group and level of performance was not significant. The comparison of performance for word recognition of body part, colour, shape, and number by group and level of performance is depicted in Figures 5.23 (a), (b), (c) and (d), respectively. Overall, the experimental group outperformed the control group in all the three levels of performance in the aforementioned assessments.



(a) Body part (b) Colour

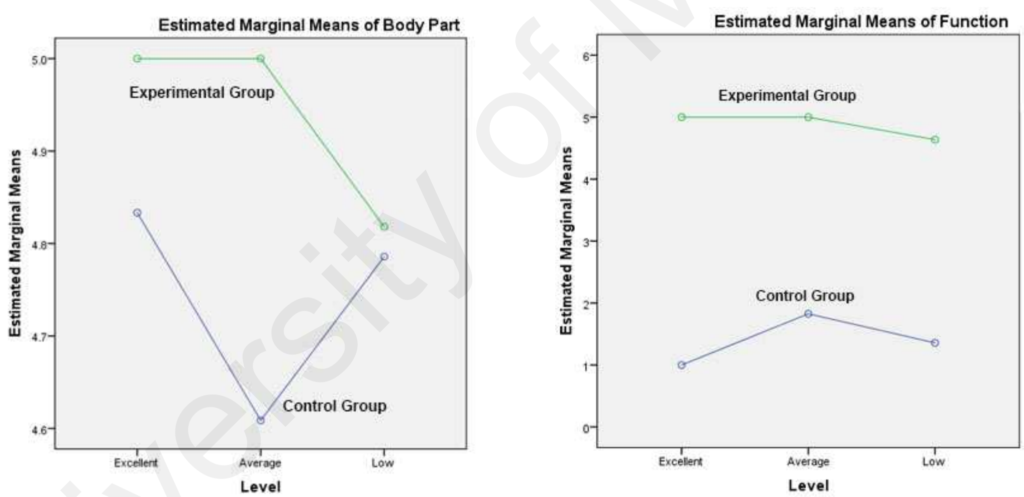
(c) Shape (d) Number

Figure 5.23: Profile plot for word recognition by group and level of performance

Table 5.12: Two-way MANOVA test for body part recognition and its function

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	Body Part	2.016[a]	5	.403	.744	.593	.045
	Function	239.888[b]	5	47.978	21.876	.000	.584
Intercept	Body Part	1553.892	1	1553.892	2864.988	.000	.973
	Function	652.335	1	652.335	297.445	.000	.792
Group	Body Part	.642	1	.642	1.184	.280	.015
	Function	201.254	1	201.254	91.765	.000	.541
Level	Body Part	.147	2	.073	.135	.874	.003
	Function	3.568	2	1.784	.813	447	.020
Group * Level	Body Part	.540	2	.270	.498	.610	.013
	Function	1.826	2	.913	.416	.661	.011
Error	Body Part	42.305	78	.542			
	Function	171.064	78	2.193			
Total	Body Part	1997.000	84				
	Function	1266.000	84				
Corrected Total	Body Part	44.321	83				
	Function	410.952	83				

a. R Squared = .045 (Adjusted R Squared = -.016)
b. R Squared = .584 (Adjusted R Squared = .557)



(a) Body part recognition (b) Function of body part

Figure 5.24: Profile plot for body part recognition and its function by group and level of performance

Q & A Game comprises the assessment of body part recognition and its function. The effect of group was significant for function of body part ($F(1,78)=91.77$, $p<0.001$, $\eta^2=0.54$) only (see Table 5.12). The comparison of the assessment of body part recognition and its function by group and level of performance was depicted in Figures

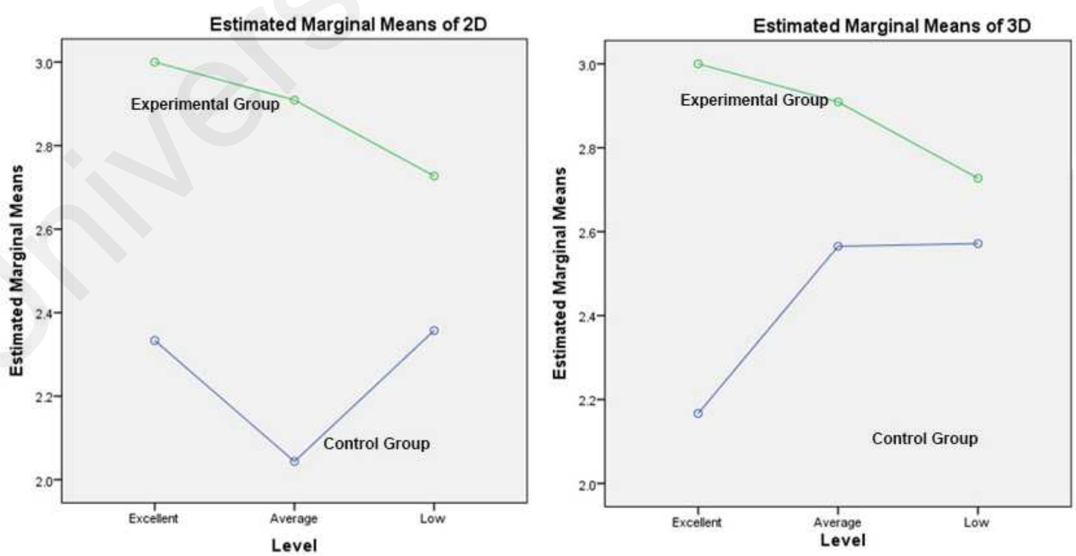
5.24 (a) and (b), respectively. Overall, the experimental group outperformed the control group in both assessments.

Cognitive Skill Assessments

Table 5.13: Two-way MANOVA test for 2D and 3D block construction

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2D	11.448[a]	5	2.290	3.001	.016	.161
	3D	4.038[b]	5	.808	2.431	.042	.135
Intercept	2D	435.127	1	435.127	570.379	.000	.880
	3D	467.961	1	467.961	1408.537	.000	.948
Group	2D	6.666	1	6.666	8.738	.004	.101
	3D	3.273	1	3.273	9.852	.002	.112
Level	2D	.389	2	.194	.255	.776	.006
	3D	.295	2	.148	.444	.643	.011
Group * Level	2D	.979	2	.489	.641	.529	.016
	3D	1.026	2	.513	1.544	.220	.038
Error	2D	59.504	78	.763			
	3D	25.914	78	.332			
Total	2D	606.000	84				
	3D	638.000	84				
Corrected Total	2D	70.952	83				
	3D	29.952	83				

a. R Squared = .161 (Adjusted R Squared = -.108)
b. R Squared = .135 (Adjusted R Squared = .079)



(a) 2D block construction (b) 3D block construction

Figure 5.25: Profile plot for 2D and 3D block constructions by group and level of performance

Building Blocks comprises two-dimensional (2D) and three-dimensional (3D) blocks constructions. The effect of group was significant for both types of block construction: 2D ($F(1,78)=8.74,\ p<0.005,\ \eta^2=0.10$) and 3D ($F(1,78)=9.85,\ p<0.005,\ \eta^2=0.11$) (see Table 5.13). The differences between groups and level of performance for 2D and 3D block constructions are depicted in Figures 5.25 (a) and (b), respectively. Although the effect of level of performance on 2D and 3D block constructions was not significant, the overall performance of the three level of performance for experimental group was better than the control group.

Table 5.14: Descriptive statistic and pairwise comparisons test for *Counting Game*

Group	Level	Mean	Std. Deviation	N
Control Group	Excellent	4.33	.516	6
	Average	3.78	1.594	23
	Low	3.00	1.617	14
	Total	3.60	1.545	43
Experimental Group	Excellent	5.00	.000	8
	Average	4.95	.213	22
	Low	4.91	.302	11
	Total	4.95	.218	41
Total	Excellent	4.71	.469	14
	Average	4.36	1.282	45
	Low	3.84	1.546	25
	Total	4.26	1.300	84

(a) Descriptive statistics

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence interval for Difference [b]	
					Lower Bound	Upper Bound
CG	EG	-1.249*	.268	.000	-1.783	-.715
EG	CG	1.249*	.268	.000	.715	1.783

CG = Control Group, EG = Experimental Group

(b) Pairwise comparisons

Counting Game is not comprised of any subtest therefore follow-up tests were carried out to evaluate pairwise differences between the adjusted means for control group and experimental group using Bonferroni adjustment. The effect of level of performance is not significant for this assessment, thus it is not examined in the follow-up test. Pairwise comparisons test indicates that the preschool children in the experimental group is better than the control group(*m=1.25, p<0.001*), as shown in Table 5.14. The differences between groups are as depicted in Figure 5.26. Although the effect of level of performance on counting skill was not significant, the overall performance of the three levels of performance for the experimental group was better than the control group.

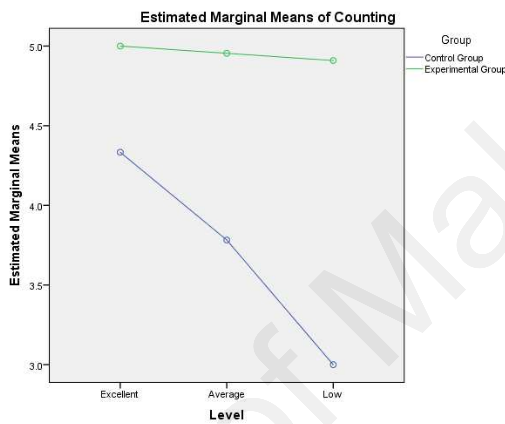


Figure 5.26: Profile plot for Counting Game by group and level of performance

Psychomotor Skill Assessments

The pairwise comparison test was chosen to compare psychomotor skills performance of the control and experimental groups. According to the MANOVA test, the effect of group was significant for body balance skill, which includes stand by left leg ($F(1,78)=4.19$, $p<0.05$, $\eta^2=0.51$) and stand by right leg ($F(1,78)=4.19$, $p<0.05$, $\eta^2=0.51$), jump forward ($F(1,78)=4.23$, $p<0.05$, $\eta^2=0.51$), and kick with left leg ($F(1,78)=4.19$, $p<0.05$, $\eta^2=0.51$) (see Table 5.15 (a)). Most of the children had no problem performing the catch ball and throw ball skills as well as the hopping. All the children could complete the running assessment. The effect of level of performance including the interaction effect between group and level of performance was not significant. Overall, the experimental group outperformed the control group for all the three levels of performance in the aforementioned assessments (see Table 5.15 (b)).

Table 5.15: MANOVA and pairwise comparisons tests for *Ball Game* and *Leg Game*

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	Catch	.230[a]	5	.046	1.001	.423	.060
	Throw	.379[b]	5	.076	1.369	.245	.081
	Left_Stand	.174[c]	5	.035	1.001	.423	.060
	Right_Stand	.174[c]	5	.035	1.001	.423	.060
	Jump Fwd	.222[d]	5	.044	.963	.446	.058
	Jump Bwd	.199[e]	5	.040	.579	.716	.036
	Left Kick	.174[f]	5	.035	1.001	.423	.060
	Right Kick	.163[g]	5	.033	1.417	.228	.083
	Running	.000[h]	5	.000	.	.	.
	Left Hop	.867[i]	5	.173	.735	.600	.045
	Right Hop	.629[j]	5	.126	.526	.756	.033
Intercept	Catch	60.320	1	60.320	1314.270	.000	.944
	Throw	60.403	1	60.403	1089.863	.000	.933
	Left_Stand	60.229	1	60.229	1728.146	.000	.957
	Right_Stand	60.229	1	60.229	1728.146	.000	.957
	Jump Fwd	59.316	1	59.316	1289.488	.000	.943
	Jump Bwd	54.889	1	54.889	796.957	.000	.911
	Left Kick	60.229	1	60.229	1728.146	.000	.957
	Right Kick	61.743	1	61.743	2690.683	.000	.972
	Running	66.306	1	66.306	.	.	.
	Left Hop	25.414	1	25.414	107.624	.000	.580
	Right Hop	27.153	1	27.153	113.519	.000	.593
Group	Catch	.017	1	.017	.365	.547	.005
	Throw	.138	1	.138	2.482	.119	.031
	Left_Stand	.146	1	.146	4.190	.044	.051
	Right_Stand	.146	1	.146	4.190	.044	.051
	Jump Fwd	.195	1	.195	4.231	.043	.051
	Jump Bwd	.022	1	.022	.319	.574	.004
	Left Kick	.146	1	.146	4.190	.044	.051
	Right Kick	.081	1	.081	3.545	.063	.043
	Running	.000	1	.000	.	.	.
	Left Hop	.000	1	.000	.001	.972	.000
	Right Hop	.035	1	.035	.146	.703	.002
Level	Catch	.179	2	.090	1.953	.149	.048
	Throw	.053	2	.026	.475	.623	.012
	Left_Stand	.040	2	.020	.572	.567	.014
	Right_Stand	.040	2	.020	.572	.567	.014
	Jump Fwd	.022	2	.011	.236	.790	.006
	Jump Bwd	.113	2	.057	.823	.443	.021
	Left Kick	.040	2	.020	.572	.567	.014
	Right Kick	.063	2	.031	1.362	.262	.034
	Running	.000	2	.000	.	.	.
	Left Hop	.395	2	.197	.836	.437	.021
	Right Hop	.486	2	.243	1.016	.367	.025

Table 5.15, continued

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Group * Level	Catch	.006	2	.003	.071	.932	.002
	Throw	.053	2	.026	.475	.623	.012
	Left_Stand	.040	2	.020	.572	.567	.014
	Right_Stand	.040	2	.020	.572	.567	.014
	Jump Fwd	.022	2	.011	.236	.790	.006
	Jump Bwd	.045	2	.023	.329	.721	.008
	Left Kick	.040	2	.020	.572	.567	.014
	Right Kick	.063	2	.031	1.362	.262	.034
	Running	.000	2	.000	.	.	.
	Left Hop	.394	2	.197	.833	.438	.021
	Right Hop	.095	2	.048	.199	.820	.005
Error	Catch	3.580	78	.046			
	Throw	4.323	78	.055			
	Left_Stand	2.718	78	.035			
	Right_Stand	2.718	78	.035			
	Jump Fwd	3.588	78	.046			
	Jump Bwd	5.372	78	.069			
	Left Kick	2.718	78	.035			
	Right Kick	1.790	78	.023			
	Running	.000	78	.000			
	Left Hop	18.418	78	.236			
	Right Hop	18.657	78	.239			
Total	Catch	80.000	84				
	Throw	79.000	84				
	Left_Stand	81.000	84				
	Right_Stand	81.000	84				
	Jump Fwd	80.000	84				
	Jump Bwd	78.000	84				
	Left Kick	81.000	84				
	Right Kick	82.000	84				
	Running	84.000	84				
	Left Hop	54.000	84				
	Right Hop	54.000	84				
Corrected Total	Catch	3.810	83				
	Throw	4.702	83				
	Left_Stand	2.893	83				
	Right_Stand	2.893	83				
	Jump Fwd	3.810	83				
	Jump Bwd	5.571	83				
	Left Kick	2.893	83				
	Right Kick	1.952	83				
	Running	.000	83				
	Left Hop	19.286	83				
	Right Hop	19.286	83				

a. R Squared = .060 (Adjusted R Squared = .000)
b. R Squared = .081 (Adjusted R Squared = .022)
c. R Squared = .060 (Adjusted R Squared = .000)
d. R Squared = .058 (Adjusted R Squared = -.002)
e. R Squared = .036 (Adjusted R Squared = -.026)
f. R Squared = .060 (Adjusted R Squared = .000)
g. R Squared = .083 (Adjusted R Squared = .024)
h. R Squared = . (Adjusted R Squared = .)
i. R Squared = .045 (Adjusted R Squared = - .016)
j. R Squared = .033 (Adjusted R Squared =- .029)

(a) MANOVA test

Table 5.15, continued

Level	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence interval for Difference [b] Lower Bound	Upper Bound
Catch	CG	EG	-.032	.053	.547	-.137	.073
	EG	CG	.032	.053	.547	-.073	.137
Throw	CG	EG	-.091	.058	.119	-.206	.024
	EG	CG	.091	.058	.119	-.024	.206
Left_Stand	CG	EG	-.094*	.046	.044	-.185	-.003
	EG	CG	.094*	.046	.044	.003	.185
Right_Stand	CG	EG	-.094*	.046	.044	-.185	-.003
	EG	CG	.094*	.046	.044	.003	.185
Jump Fwd	CG	EG	-.108*	.053	.043	-.213	-.003
	EG	CG	.108*	.053	.043	.003	.213
Jump Bwd	CG	EG	-.036	.064	.574	-.165	.092
	EG	CG	.036	.064	.574	-.092	.165
Left Kick	CG	EG	-.094*	.046	.044	-.185	-.003
	EG	CG	.094*	.046	.044	.003	.185
Right Kick	CG	EG	-.070	.037	.063	-.144	.004
	EG	CG	.070	.037	.063	-.004	.144
Running	CG	EG	-8.693E-17	.000	.	-8.693E-17	-8.693E-17
	EG	CG	8.693E-17	.000	.	8.693E-17	8.693E-17
Left Hop	CG	EG	-.004	.119	.972	-.242	233
	EG	CG	.004	.119	.972	-.233	.242
Right Hop	CG	EG	-.046	.120	.703	-.285	.193
	EG	CG	.046	.120	.703	-.193	.285

CG = Control Group, EG = Experimental Group
Based on estimated marginal means
*. The mean difference is significant at the.05 level.
b. Adjustment for multiple comparisons: Bonferroni.

(b) Pairwise comparisons test

5.3.4.3 Correlational Analyses for Physical Game Assessment

Correlations were computed with seven assessments in *Physical Game Assessment*, which covered the evaluation of language and communication (*Card Game* (colour, shape, and number), *Puzzle* (body part), *Q &A Game* (recognition of body part and function), cognitive skills (*Building Blocks* (2D and 3D) and *Counting Game*), and psychomotor skills (*Ball Game* and *Leg Game*).

Three correlational analyses were conducted to examine associations of language and communication and cognitive skills, language and communication and psychomotor skills, and lastly cognitive and psychomotor skills. The results show that there is an association among all the areas of development at different degrees of correlation.

Correlational Analysis for Language and Communication and Cognitive Skills

For the correlational analysis between language and communication and cognitive skills, the results showed that 24 out of 36 correlations were statistically significant (see Table 5.16). 18 correlations were greater or equal to $r(82)=0.28$, $p<0.01$, *two-tailed* while the remaining 6 correlations were greater or equal to $r(82)=0.22$, $p<0.05$, *two-tailed*. This suggests that language and communication skills and cognitive skills are positively correlated.

Table 5.16: Correlational analysis for language and communication and cognitive skills

		Body Part	Colour	Shape	Number	Recognition of Body Part	Body Part's Function	3D Model	2D Model	Counting
Body Part	Pearson Correlation	1	.258*	.245*	.427**	.047	.282**	.336**	.347**	.293**
	Sig. (2-tailed)		.018	.024	.000	.669	.009	.002	.001	.007
	N	84	84	84	84	84	84	84	84	84
Colour	Pearson Correlation		1	.584**	.569**	-.011	.176	-.014	.238*	.332**
	Sig. (2-tailed)			.000	.000	.920	.110	.903	.030	.002
	N		84	84	84	84	84	84	84	84
Shape	Pearson Correlation			1	.452**	-.017	.453**	.244*	.453**	.461**
	Sig. (2-tailed)				.000	.876	.000	.025	.000	.000
	N			84	84	84	84	84	84	84
Number	Pearson Correlation				1	-.006	.161	.130	.154	.448**
	Sig. (2-tailed)					.955	.144	.239	.162	.000
	N				84	84	84	84	84	84
Recognition of Body Part	Pearson Correlation					1	.340**	.010	.015	-.064
	Sig. (2-tailed)						.002	.929	.890	.561
	N					84	84	84	84	84
Body Part's Function	Pearson Correlation						1	.279*	.425**	.457**
	Sig. (2-tailed)							.010	.000	.000
	N						84	84	84	84
3D Model	Pearson Correlation							1	.361**	.229*
	Sig. (2-tailed)								.001	.037
	N							84	84	84
2D Model	Pearson Correlation								1	.346**
	Sig. (2-tailed)									.001
	N								84	84
Counting	Pearson Correlation									1
	Sig. (2-tailed)									
	N									84

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Correlational Analysis for Language and Communication and Psychomotor Skills

There are several correlations found between language and communication and psychomotor skills. The knowledge of colour has negative correlation with hopping (right hop) *r(82)=-0.24, p<0.05, two-tailed* (see Table 5.17). 4 positive correlations found were less than *r(82)=0.25, p<0.05, two-tailed* among the knowledge of shape and psychomotor skills (throw ball, body balance, and jumping skills). This suggests that there is a weak relationship between language and communication and psychomotor skills.

Table 5.17: Correlational analysis for language and communication and psychomotor skills

		Throw Ball	Left_Stand	Right_Stand	JumpFwd	RightHop
Body Part	Pearson Correlation	.158	-.047	-.047	.159	.103
	Sig. (2-tailed)	.151	.672	.672	.149	.351
	N	84	84	84	84	84
Colour	Pearson Correlation	.205	.131	.131	.076	-.236*
	Sig. (2-tailed)	.061	.236	.236	.492	.030
	N	84	84	84	84	84
Shape	Pearson Correlation	.225*	.237*	.237*	.248*	.019
	Sig. (2-tailed)	.040	.030	.030	.023	.862
	N	84	84	84	84	84
Number	Pearson Correlation	.174	-.005	-.005	.034	-.090
	Sig. (2-tailed)	.113	.964	.964	.756	.413
	N	84	84	84	84	84

* Correlation is significant at the 0.05 level (2-tailed).

Correlational Analysis for Cognitive and Psychomotor Skills

The correlational analysis for cognitive and psychomotor skills showed that 48 out of 78 correlations were statistically significant (see Table 5.18). 37 correlations were greater or equal to *r(82)=0.28, p<0.01, two-tailed* while the remaining 11 correlations were greater or equal to *r(82)=0.21, p<0.05, two-tailed*. This suggests that cognitive and psychomotor skills are positively correlated.

Table 5.18: Correlational analysis for cognitive and psychomotor skills

		Block construction	Counting	Catch Ball	Throw Ball	Left Stand	Right Stand	Jump Fwd	Jump Bwd	Left Kick	Right Kick	Running	Left Hop	Right Hop
Block construction	Pearson Correlation	1	.359**	.259*	.321**	.185	.185	.215*	.157	.134	.008	.[c]	-.031	-.011
	Sig. (2-tailed)		.001	.017	.003	.092	.092	.050	.154	.224	.425	.	.780	.919
	N	84	84	84	84	84	84	84	84	84	84	84	84	84
Counting	Pearson Correlation		1	.262*	.285**	.188	.188	.262*	.164	.138	.032	.[c]	.036	.036
	Sig. (2-tailed)			.016	.009	.087	.087	.016	.137	.210	.775	.	.747	.747
	N		84	84	84	84	84	84	84	84	84	84	84	84
Catch Ball	Pearson Correlation			1	.416**	.559**	.559**	.475**	.589**	.589**	.332**	.[c]	.300**	.300**
	Sig. (2-tailed)				.000	.000	.000	.000	.000	.000	.002	.	.006	.006
	N			84	84	84	84	84	84	84	84	84	84	84
Throw Ball	Pearson Correlation				1	494**	.494**	416**	.321**	.223*	.291	.[c]	.023	.023
	Sig. (2-tailed)					.000	.000	.000	.003	.042	.007	.	.839	.839
	N				84	84	84	84	84	84	84	84	84	84
Left Stand	Pearson Correlation					1	1.000**	.861**	.694**	.654**	.812**	.[c]	.258*	.258*
	Sig. (2-tailed)						.000	.000	.000	.000	.002	.	.018	.018
	N					84	84	84	84	84	84	84	84	84
Right Stand	Pearson Correlation						1	.861**	.694**	.654**	.812**	.[c]	.258*	.258*
	Sig. (2-tailed)							.000	.000	.000	.002	.	.018	.018
	N						84	84	84	84	84	84	84	84
Jump Fwd	Pearson Correlation							1	.806**	.559**	.698**	.[c]	.300**	.300**
	Sig. (2-tailed)								.000	.000	.000	.	.006	.006
	N							84	84	84		84	84	84
Jump Bwd	Pearson Correlation								1	.445**	.563**	.[c]	.372**	.372**
	Sig. (2-tailed)									.000	.000	.	.000	.000
	N								84	84	84	84	84	84
Left Kick	Pearson Correlation									1	.812**	.[c]	.258*	.258*
	Sig. (2-tailed)										.000	.	.018	.018
	N									84	84	84	84	84
Right Kick	Pearson Correlation										1	.[c]	.210	.210
	Sig. (2-tailed)											.	.056	.056
	N										84	84	84	84

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Table 5.18, continued

		Block construction	Counting	Catch Ball	Throw Ball	Left Stand	Right Stand	Jump Fwd	Jump Bwd	Left Kick	Right Kick	Running	Left Hop	Right Hop
Running	Pearson Correlation	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]	.[c]
	Sig. (2-tailed)	.	.	.	.	.	.	.	.	.	.	.	.	.
	N	84	84	84	84	84	84	84	84	84	84	84	84	84
Left Hop	Pearson Correlation												1	.793**
	Sig. (2-tailed)													.000
	N												84	84
Right Hop	Pearson Correlation													1
	Sig. (2-tailed)													
	N													84

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed).

5.3.4.4 Multiple Regression Analyses for Physical Game Assessment

Regression Analysis for Language and Communication Skill

A multiple regression was run to predict the language and communication skills based on five predictors: language (colour, shape, and number) and communication (recognition of body part and function). The combination of number knowledge and body part's function was significantly related to body part knowledge, $F(2,81)=12.054$, $p<0.001$ (see Table 5.19 (b)). This two predictors model was able to account for 22.9% ($R^2=0.229$) of the variance (see Table 5.19 (a)). The significant level of association for number knowledge and body part is at $p<0.001$ and $p<0.05$ respectively (see Table 5.19 (c)).

Table 5.19: Multiple regression analysis for language and communication

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.427[a]	.183	.173	1.119
2	.479[b]	.229	.210	1.093

a. Predictors: (Constant), Number
b. Predictors: (Constant), Number, Function

(a) Model summary

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	22.924	1	22.924	18.315	.000[b]
	Residual	102.636	82	1.252		
	Total	125.560	83			
2	Regression	28.799	2	14.400	12.054	.000[c]
	Residual	96.760	81	1.195		
	Total	125.560	83			

b. Predictors: (Constant), Number
c. Predictors: (Constant), Number, Function

(b) ANOVA test

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.257	.287		11.345	.000
	Number	.375	.088	.427	4.280	.000
2	(Constant)	2.962	.310		9.544	.000
	Number	.344	.087	.392	3.967	.000
	Function	.121	.055	.219	2.218	.029

(c) Coefficients test

Regression Analysis for Cognitive Skill

A multiple regression model with seven predictors: language (knowledge of body part, colour, shape, and number), communication (recognition of body part and function), and cognitive skill (counting), was run to predict the cognitive skill (*Building Blocks*). The combination of body part, shape, and body part's function was significantly related to the building block skill, $F(3,80)=13.713,\ p<0.001$ (see Table 5.20 (b)). This three predictors model was able to account for 34% ($R^2=0.34$) of the variance (see Table 5.20 (a)). All the predictors significantly predict the building block skill at $p<0.05$ (see Table 5.20 (c)).

Table 5.20: Multiple regression analysis for block construction skill (I)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.445[a]	.198	.188	3.436
2	.543[b]	.295	.278	3.242
3	.583[c]	.340	.315	3.157

a. Predictors: (Constant), Shape
b. Predictors: (Constant), Shape, Body Part
c. Predictors: (Constant), Shape, Body Part, Function

(a) Model summary

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	238.942	1	238.942	20.234	.000[b]
	Residual	968.344	82	11.809		
	Total	1207.286	83			
2	Regression	356.050	2	178.025	16.940	.000[c]
	Residual	851.236	81	10.509		
	Total	1207.286	83			
3	Regression	409.994	3	136.665	13.713	.000[d]
	Residual	797.292	80	9.966		
	Total	1207.286	83			

b. Predictors: (Constant), Shape
c. Predictors: (Constant), Shape, Body Part
d. Predictors: (Constant), Shape, Body Part, Function

(b) ANOVA test

Table 5.20, continued

	Model	Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	11.943	.904		13.214	.000
	Shape	1.219	.271	.445	4.498	.000
2	(Constant)	8.247	1.398		5.900	.000
	Shape	1.003	.264	.366	3.803	.000
	Body Part	.996	.298	.321	3.338	.001
3	(Constant)	8.341	1.362		6.126	.000
	Shape	.732	.282	.267	2.598	.011
	Body Part	.860	.296	.277	2.900	.005
	Function	.415	.178	.242	2.327	.023

(c) Coefficients test

The multiple regression analysis was run to predict the block construction skill based on the ball skill (catch and throw). Ball skills was significantly related to the block construction skill, $F(2,81)=8.054$, $p<0.005$, $R^2=0.166$ (see Table 5.21 (a) and (b)). The analysis shows that only the catch ball skill significantly predicted the 2D model block construction skill, $p<0.05$ (see Table 5.21 (c)).

Table 5.21: Multiple regression analysis for block construction skill (II)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.407[a]	.166	.145	.855

a. Predictors: (Constant), Throw, Catch

(a) Model summary

	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11.769	2	5.885	8.054	.001[b]
	Residual	59.183	81	.731		
	Total	70.952	83			

b. Predictors: (Constant), Throw, Catch

(b) ANOVA test

	Model	Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.640	.479		1.335	.186
	Catch	1.267	.482	.294	2.630	.010
	Throw	.720	.434	.185	1.661	.101

(c) Coefficients test

The multiple regression was conducted to develop a model for predicting preschool children's counting skills from their knowledge of number and language and communication skill (recognition and of body part and function). The linear combination of colour, shape, and number knowledge was significantly related to the block construction skill, *$F(3,80)=17.581$, $p<0.001$* (see Table 5.22 (b)). The results of the regression indicated the three predictors explained 39.7% of the variance ($R^2=0.397$) (see Table 5.22 (a)). All three predictors significantly predict the block construction skill at $p<0.05$ (see Table 5.22 (c)).

Table 5.22: Multiple regression analysis for counting skill (I)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.630[a]	.397	.375	1.028

a. Predictors: (Constant), Function, Number, Body Part

(a) Model summary

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	55.721	3	18.574	17.581	.000[b]
	Residual	84.517	80	1.056		
	Total	140.238	83			

b. Predictors: (Constant), Function, Number, Body Part

(b) ANOVA test

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.270	.804		5.314	.000
	Number	.344	.082	.371	4.210	.000
	Body Part	-.396	.165	-.223	-2.410	.018
	Function	.277	.055	.474	5.054	.000

(c) Coefficients test

The analysis was continued with block construction skill (2D and 3D) to examine its relationship with counting skills. The block construction skill significantly predicted counting skills, *$F(2,81)=6.152$, $p<0.01$, $R^2=0.132$* (see Table 5.23 (a) and (b)). The results show that only 2D model block construction skill can predict the acquisition of counting skill at a statistically significant level, $p<0.01$ (see Table 5.23 (c)).

Table 5.23: Multiple regression analysis for counting skill (II)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.363[a]	.132	.110	1.226

a. Predictors: (Constant), 2D, 3D

(a) Model summary

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18.492	2	9.246	6.152	.003[b]
	Residual	121.746	81	1.503		
	Total	140.238	83			

b. Predictors: (Constant), 2D, 3D

(b) ANOVA test

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	2.493	.638		3.908	.000
	2D	.258	.240	.119	1.076	.285
	3D	.425	.156	.303	2.726	.008

(c) Coefficients test

Regression Analysis for Psychomotor Skill

A multiple regression analysis was conducted to develop a model for predicting preschool children's body balance skills based on other motor skills such as ball skills (catch ball and throw ball) and gross motor skills (jumping, kicking, and hopping). Ball skills was significantly related to the body balance skill, $R^2=0.888$, $F(8,75)=74.191$, $p<0.001$ (see Table 5.24 (a) and (b)). All the predictors except for throw ball and hopping (left hop and right hop) were statistically significant for the prediction, $p<0.05$ (see Table 5.24 (c)).

Table 5.24: Multiple regression analysis for body balance skill

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.942[a]	.888	.876	.132

a. Predictors: (Constant), Right Hop, Throw Ball, Left Kick, Jump Bwd, Catch Ball, Left Hop, Jump Fwd, Right Kick

(a) Model summary

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10.273	8	1.284	74.191	.000[b]
	Residual	1.298	75	.017		
	Total	11.571	83			

b. Predictors: (Constant), Right Hop, Throw Ball, Left Kick, Jump Bwd, Catch Ball, Left Hop, Jump Fwd, Right Kick

(b) ANOVA test

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	-.351	.108		-3.245	.002
	Catch Ball	.596	.118	.342	5.045	.000
	Throw Ball	.105	.074	.067	1.425	.158
	Jump Fwd	.947	.137	.544	6.931	.000
	Jump Bwd	-.299	.114	-.207	-2.625	.011
	Left Kick	-.597	.179	-.298	-3.333	.001
	Right Kick	1.597	.222	.656	7.186	.000
	Left Hop	.003	.050	.004	.067	.947
	Right Hop	.003	.050	.004	.067	.947

(c) Coefficients test

5.3.4.5 Analysis of Virtual Game Assessment

Virtual Game Assessment consists of five assessments: *Body Journey*, *Colour World*, *House of Shape*, *Number Hut*, and *Treasure Hunt*. *Body Journey*, *Colour World*, *House of Shape*, and *Number Hut* assess language and communication and cognitive skills whereas *Treasure Hunt* is for psychomotor skills assessment.

The analysis of preschool children's performance in *Virtual Game Assessment* was started by investigating the effect of gender and level of performance using the two-way ANOVA test. This analysis did not examine for group effect as only the experimental group sat for this assessment. There was no significant difference from the effect of gender and level of performance as well as from the interaction of these two effects (see Table 5.25).

Table 5.25: Two-way ANOVA test for *Virtual Game Assessment*

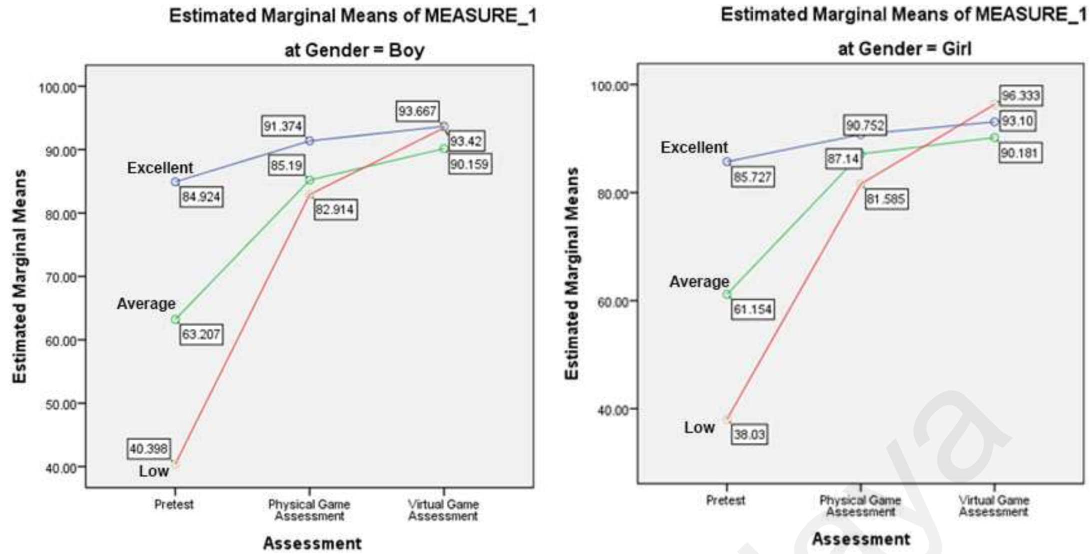
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	159.651[a]	5	31.930	.363	.870	.049
Intercept	262857.075	1	262857.075	2986.635	.000	.988
Sex	4.760	1	4.760	.054	.817	.002
Level	157.484	2	78.742	.895	.418	.049
Sex * Level	16.000	2	8.000	.091	.913	.005
Error	3080.389	35	88.011			
Total	349279.026	41				
Corrected Total	3240.040	40				

A two-way MANOVA test was carried out to examine the preschool children's overall performance in all the three assessments, which include pre-test, physical game assessment, and virtual game assessment. The mean score of the assessments was statistically significant (*F(2,34)=157.98, p=0.000, Wilks'Λ=0.097*) and the interaction of level of performance on the assessment was significant (*F(4,68)=17.32, p=0.000, Wilks'Λ=0. 245*) as well (see Table 5.26).

Table 5.26: Two-way MANOVA test for three assessments

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Student Performance	Pillai's Trace	.903	157.981[b]	2.000	34.000	.000	.903
	Wilks's Lambda	.097	157.981[b]	2.000	34.000	.000	.903
	Hotelling's Trace	9.293	157.981[b]	2.000	34.000	.000	.903
	Roy's Largest Root	9.293	157.981[b]	2.000	34.000	.000	.903
Student Performance * Sex	Pillai's Trace	.007	.128[b]	2.000	34.000	.880	.007
	Wilks's Lambda	.993	.128[b]	2.000	34.000	.880	.007
	Hotelling's Trace	.008	.128[b]	2.000	34.000	.880	.007
	Roy's Largest Root	.008	.128[b]	2.000	34.000	.880	.007
Student Performance * Level	Pillai's Trace	.774	11.052	4.000	70.000	.000	.387
	Wilks's Lambda	.245	17.318[b]	4.000	68.000	.000	.505
	Hotelling's Trace	2.995	24.714	4.000	66.000	.000	.600
	Roy's Largest Root	2.969	51.951[c]	2.000	35.000	.000	.748
Student Performance * Sex * Level	Pillai's Trace	.034	.304	4.000	70.000	.874	.017
	Wilks's Lambda	.966	.296[b]	4.000	68.000	.879	.017
	Hotelling's Trace	.035	.288	4.000	66.000	.885	.017
	Roy's Largest Root	.025	.444[c]	2.000	35.000	.645	.025

b. Exact statistic
c. The statistic is an upper bound on F that yields a lower bound on the significance level.



(a) Boys' performance (b) Girls' performance

Figure 5.27: Profile plot for three assessments by gender and level of performance

The comparison of the assessments between boys and girls by level of performance is depicted in Figures 5.27 (a) and (b), respectively. The children (boys and girls) with *Excellent* performance showed improvements in both the post-tests, *Physical Game Assessment* (m_{boy}= 91.37, m_{girl}= 90.75) and *Virtual Game Assessment* (m_{boy}= 93.67, m_{girl}= 93.10) compared with their pre-test (m_{boy}= 84.92, m_{girl}= 85.73). The children (boys and girls) with *Average* performance also showed improvements in both the post-tests, *Physical Game Assessment* (m_{boy}= 85.19, m_{girl}= 87.14) and *Virtual Game Assessment* (m_{boy}= 90.16, m_{girl}= 90.18) compared with their pre-test (m_{boy}= 63.21, m_{girl}= 61.15). The children (boys and girls) with *Low* performance demonstrated great improvements in the two post-tests, *Physical Game Assessment* (m_{boy}= 82.91, m_{girl}= 81.59) and *Virtual Game Assessment* (m_{boy}= 93.42, m_{girl}= 96.33) compared with their pre-test (m_{boy}= 40.40, m_{girl}= 38.03). Boys with *Low* performance outperformed boys with *Average* performance in *Virtual Game Assessment*. Girls with *Low* performance surpassed girls with *Excellent* and *Average* performances in *Virtual Game Assessment*.

Analysis of Language and Communication Skill Performance

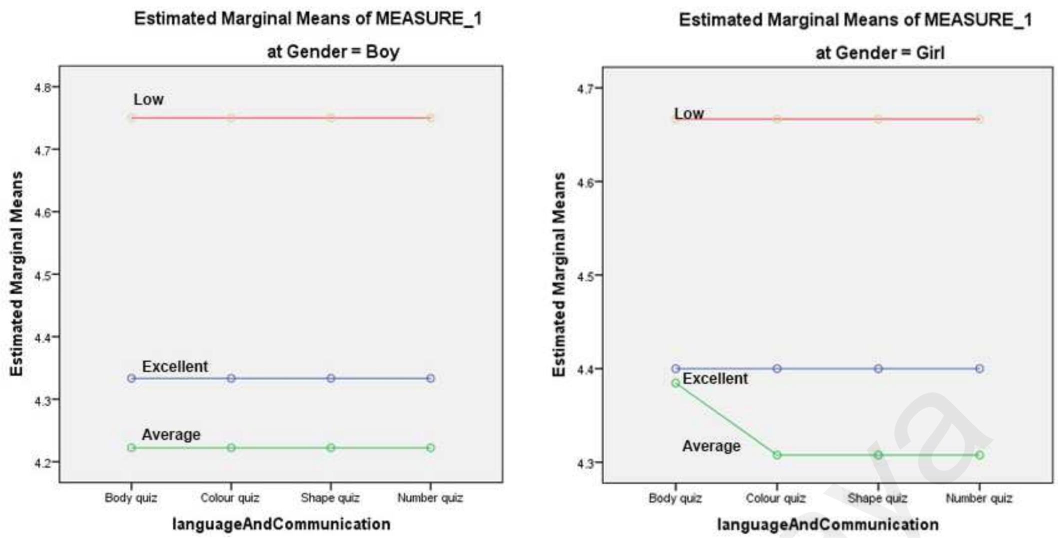
The results were then further analysed for the effect of gender and level of performance in each area of development (language and communication, cognitive, and psychomotor skill). The MANOVA analysis showed that there was a statistically significant interaction between the effects of level of performance on language and communication skills, $F(2,35)=3.48$, $p=0.042$, $Wilks'\Lambda=0.834$ (see Table 5.27).

Table 5.27: MANOVA test for language and communication skill

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Language and communication	Pillai's Trace	.001	.029[b]	1.000	35.000	.866	.001
	Wilks's Lambda	.999	.029[b]	1.000	35.000	.866	.001
	Hotelling's Trace	.001	.029[b]	1.000	35.000	.866	.001
	Roy's Largest Root	.001	.029[b]	1.000	35.000	.866	.001
Language and communication * Sex	Pillai's Trace	.001	.051[b]	1.000	35.000	.823	.001
	Wilks's Lambda	.999	.051[b]	1.000	35.000	.823	.001
	Hotelling's Trace	.001	.051[b]	1.000	35.000	.823	.001
	Roy's Largest Root	.001	.051[b]	1.000	35.000	.823	.001
Language and communication * Level	Pillai's Trace	,166	3.482[b]	2.000	35.000	.042	.166
	Wilks's Lambda	.834	3.482[b]	2.000	35.000	.042	.166
	Hotelling's Trace	.199	3.482[b]	2.000	35.000	.042	.166
	Roy's Largest Root	.199	3.482[b]	2.000	35.000	.042	.166
Language and communication * Sex * Level	Pillai's Trace	.011	.202[b]	2.000	35.000	.818	.011
	Wilks's Lambda	.989	.202[b]	2.000	35.000	.818	.011
	Hotelling's Trace	.012	.202[b]	2.000	35.000	.818	.011
	Roy's Largest Root	.012	.202[b]	2.000	35.000	.818	.011

b. Exact statistic

The assessment of language and communication in *Virtual Game Assessment* comprised *Body Quiz*, *Colour Quiz*, *Shape Quiz*, and *Number Quiz*. Figures 5.28 (a) and (b) were used to illustrate the differences in performance in each assessment between boys and girls respectively by level of performance. Boys and girls with *Low* performance outperformed boys and girls with *Excellent* and *Average* performances in *Body Quiz*, *Colour Quiz*, *Shape Quiz*, and *Number Quiz.*



(a) Boys' performance (b) Girls' performance

Figure 5.28: Profile plot for language and communication's performance by gender and level of performance

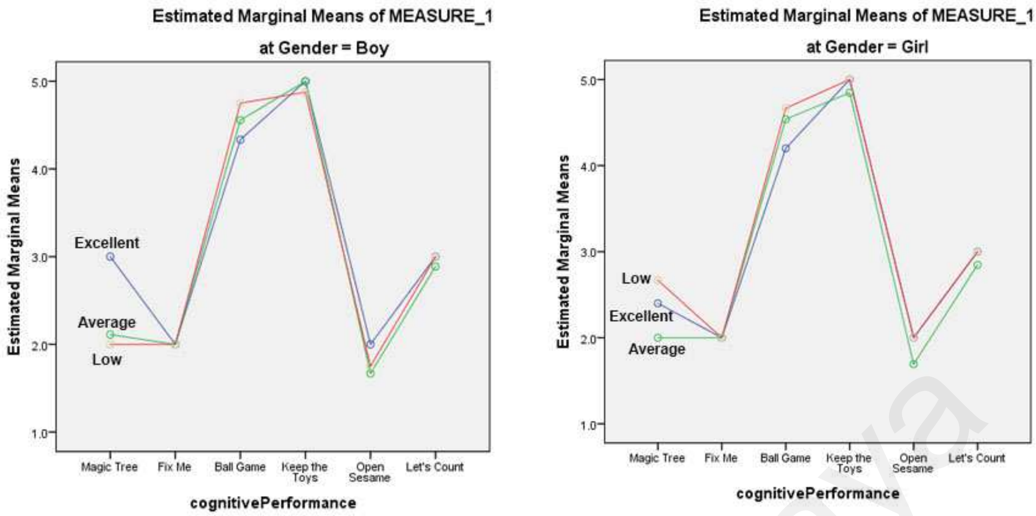
Analysis of Cognitive Skill Performance

The assessment of cognitive skill consisted of *Magic Tree*, *Fix Me*, *Ball Game*, *Keep the Toys*, *Open Sesame*, and *Let's Count*. There were no differences found for gender and level of performance for cognitive skill (see Table 5.28).

Table 5.28: MANOVA test for cognitive skill

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Cognitive skill	Pillai's Trace	.069	2.606[b]	1.000	35.000	.115	.069
	Wilks's Lambda	.931	2.606[b]	1.000	35.000	.115	.069
	Hotelling's Trace	.074	2.606[b]	1.000	35.000	.115	.069
	Roy's Largest Root	.074	2.606[b]	1.000	35.000	.115	.069
Cognitive skill * Sex	Pillai's Trace	.016	.564[b]	1.000	35.000	.458	.016
	Wilks's Lambda	.984	.564[b]	1.000	35.000	.458	.016
	Hotelling's Trace	.016	.564[b]	1.000	35.000	.458	.016
	Roy's Largest Root	.016	.564[b]	1.000	35.000	.458	.016
Cognitive skill * Level	Pillai's Trace	.058	1.087[b]	2.000	35.000	.348	.058
	Wilks's Lambda	.942	1.087[b]	2.000	35.000	.348	.058
	Hotelling's Trace	.062	1.087[b]	2.000	35.000	.348	.058
	Roy's Largest Root	.062	1.087[b]	2.000	35.000	.348	.058
Cognitive skill * Sex * Level	Pillai's Trace	.016	.278[b]	2.000	35.000	.759	.016
	Wilks's Lambda	.984	.278[b]	2.000	35.000	.759	.016
	Hotelling's Trace	.016	.278[b]	2.000	35.000	.759	.016
	Roy's Largest Root	.016	.278[b]	2.000	35.000	.759	.016

b. Exact statistic



(a) Boys' performance (b) Girls' performance

Figure 5.29: Profile plot for cognitive skill performance by gender and level of performance

Figures 5.29 (a) and (b) were used to illustrate the differences in performance in the assessment between boys and girls respectively by level of performance. Boys with *Excellent* performance performed well in the assessments that required problem solving skills (*Magic Tree*, *Fix Me*, *Open Sesame*, and *Let's Count*) whereas boys with *Average* and *Low* performances achieved better results in decision-making assessments (*Ball Game* and *Keep the Toys*). Overall, girls with *Excellent* and *Low* performances achieved better results when compared to girls with *Average* performance for all the assessments.

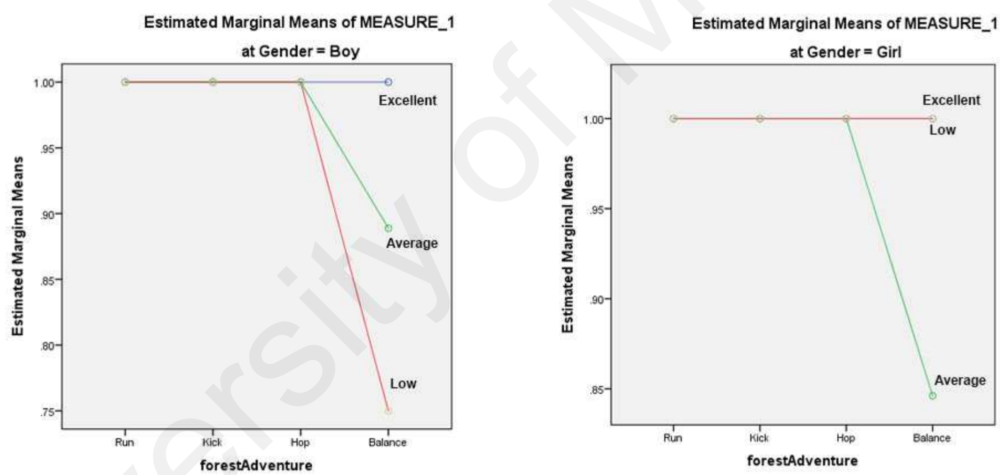
Analysis of Psychomotor Skill Performance

The interaction effect of psychomotor skill, gender, and level of performance was significant, $F(2,35)=3.77, p=0.033, Wilks'\Lambda=0.823$ (see Table 5.29). The psychomotor skill assessment comprised *Forest Adventure* (*Run*, *Kick*, *Hop*, and *Balance*), *River Adventure* (*Jump*, *Catch*, and *Throw*), and *Treasure Box* (*Push* and *Pull*). Figures 5.30 (a) and (b) were used to illustrate the differences in performance for *Forest Adventure*. All the children were able to perform the actions of *Run*, *Kick*, and *Hop* except *Balance*.

Table 5.29: Two-way ANOVA test for psychomotor skill

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Psychomotor	Pillai's Trace	.811	150.564^{b}	1.000	35.000	.000	.811
	Wilks's Lambda	.189	150.564^{b}	1.000	35.000	.000	.811
	Hotelling's Trace	4.302	150.564^{b}	1.000	35.000	.000	.811
	Roy's Largest Root	4.302	150.564^{b}	1.000	35.000	.000	.811
Psychomotor * Sex	Pillai's Trace	.015	.523^{b}	1.000	35.000	.474	.015
	Wilks's Lambda	.985	.523^{b}	1.000	35.000	.474	.015
	Hotelling's Trace	.015	.523^{b}	1.000	35.000	.474	.015
	Roy's Largest Root	.015	.523^{b}	1.000	35.000	.474	.015
Psychomotor * Level	Pillai's Trace	.034	.611^{b}	2.000	35.000	.548	.034
	Wilks's Lambda	.966	.611^{b}	2.000	35.000	.548	.034
	Hotelling's Trace	.035	.611^{b}	2.000	35.000	.548	.034
	Roy's Largest Root	.035	.611^{b}	2.000	35.000	.548	.034
Psychomotor * Sex * Level	Pillai's Trace	.177	3.771^{b}	2.000	35.000	.033	.177
	Wilks's Lambda	.823	3.771^{b}	2.000	35.000	.033	.177
	Hotelling's Trace	.215	3.771^{b}	2.000	35.000	.033	.177
	Roy's Largest Root	.215	3.771^{b}	2.000	35.000	.033	.177

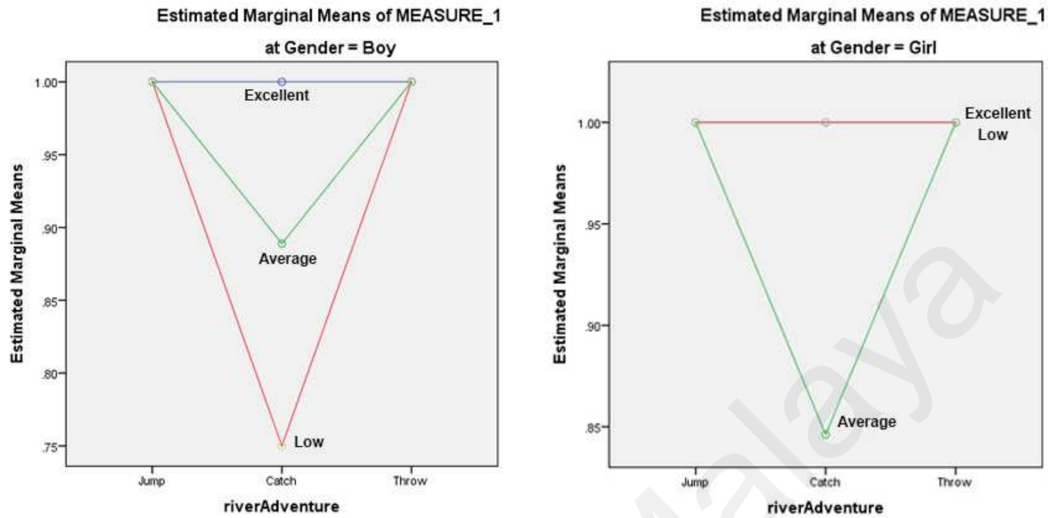
b. Exact statistic



(a) Boys' performance (b) Girls' performance

Figure 5.30: Profile plot for the performance of *Forest Adventure* by gender and level of performance

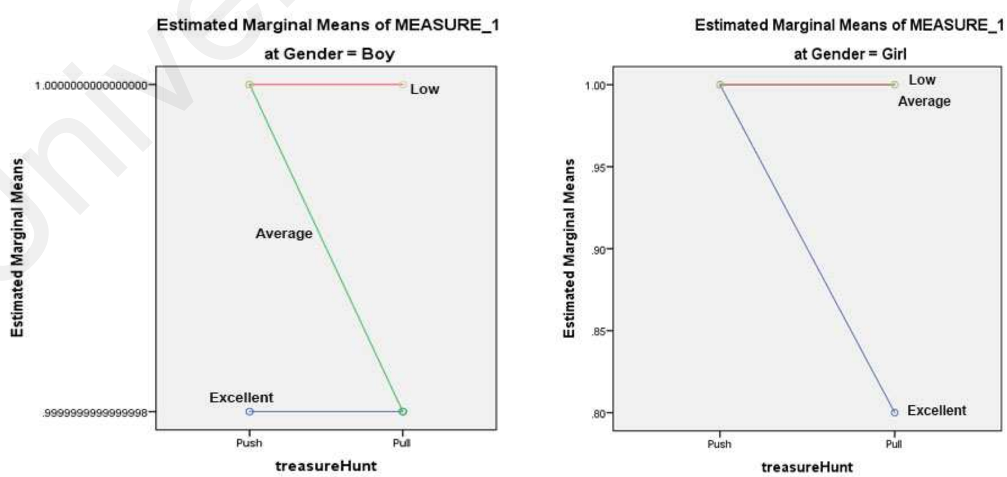
Figures 5.31 (a) and (b) were used to illustrate the differences in performance for *River Adventure*. For boys, those with *Excellent* performance were able to perform the *Jump*, *Catch*, and *Throw* actions correctly whereas some of boys with *Low* and *Average* performances could not perform the *Catch* assessment correctly. On the other hand, girls with *Excellent* and *Low* performances completed the *Jump*, *Catch*, and *Throw* assessments successfully. However, some of the girls with *Average* performance fared poorly in the *Catch* assessment.



(a) Boys' performance (b) Girls' performance

Figure 5.31: Profile plot for the performance of *River Adventure* by gender and level of performance

The differences in performance for *Treasure Box* by gender and level of performance are depicted in Figures 5.32 (a) and (b).Almost all of the children were able to perform the action of *Push* and *Pull*. The boys' mean for *Excellent* and *Average* performances approximate to 1 and the girls' mean for *Excellent* performance is 0.8.



(a) Boys' performance (b) Girls' performance

Figure 5.32: Profile plot for the performance of *Treasure Box* by gender and level of performance

5.3.4.6 Correlational Analyses for Virtual Game Assessment

Correlational analysis was conducted for all the assessments (*Body Journey*, *Colour World*, *House of Shape*, *Number Hut*, and *Treasure Hunt*) in *Virtual Game Assessment.* The analysis aimed to investigate the association between language and communication (*Body Quiz*, *Colour Quiz*, *Shape Quiz*, and *Number Quiz*), cognitive skills (*Magic Tree*, *Fix Me*, *Ball Game*, *Keep the Toys*, *Open Sesame*, and *Let's Count*) and psychomotor skills (*Run*, *Kick*, *Hop*, *Balance*, *Jump*, *Catch*, *Throw*, *Push*, and *Pull*). Two associations were found at different degree of correlation: (1) language and communication and cognitive skills and (2) cognitive and psychomotor skills. However, the correlation between language and communication and psychomotor skills is not significant.

Correlational Analysis among Areas of Development

For the correlational analysis, 15 out of 66 correlations were statistically significant (see Table 5.30). For language and communication, no correlation was found with cognitive skills nor with psychomotor skills. However, the 6 out of 15 correlations were statistically significant for cognitive and psychomotor skills. All the correlations were greater or equal to $r(39)=0.44$, $p<0.01$, *two-tailed*. This suggests that cognitive skill has positive and moderate ($r>0.3$) correlation with psychomotor skill.

All the four language and communication assessments were highly correlated, greater or equal to $r(39)=0.98$, $p<0.01$, *two-tailed*. This suggests that the learning of body part, colour, shape, and number are highly correlated. For psychomotor skill, catch ball skill has perfect correlation with balance skill ($r=1$). The result implies that the children who possess catch ball skill are more likely to have the body balance skill too.

Table 5.30: Correlations analysis for *Virtual Game Assessment*

		Body Quiz	Magic Tree	Colour Quiz	Ball Game	Shape Quiz	Keep the Toys	Number Quiz	Open Sesame	Let's Count	Catch	Balance	Pull
Body Quiz	Pearson Correlation	1	.165	.985**	.252	.985**	.080	.985**	.200	.037	.205	.205	.087
	Sig. (2-tailed)		.303	.000	.111	.000	.618	.000	.211	.817	.198	.198	.589
	N	41	41	41	41	41	41	41	41	41	41	41	41
Magic Tree	Pearson Correlation		1	.126	.256	.126	.178	.126	.375*	.291	.445**	.445**	.037
	Sig. (2-tailed)			.432	.107	.432	.265	.432	.016	.065	.004	.004	.818
	N		41	41	41	41	41	41	41	41	41	41	41
Colour Quiz	Pearson Correlation			1	.218	1.000**	-.083	1.000**	.176	.027	.181	.181	.077
	Sig. (2-tailed)				.170	.000	.607	.000	.271	.868	.258	.258	.634
	N			41	41	41	41	41	41	41	41	41	41
Ball Game	Pearson Correlation				1	.218	-.048	.218	-.219	-.169	-.225	-.225	-.095
	Sig. (2-tailed)					.170	.768	.170	.169	.289	.158	.158	.553
	N				41	41	41	41	41	41	41	41	41
Shape Quiz	Pearson Correlation					1	-.083	1.000**	.176	.027	.181	.181	.077
	Sig. (2-tailed)						.607	.000	.271	.868	.258	.258	.634
	N					41	41	41	41	41	41	41	41
Keep the Toys	Pearson Correlation						1	-.083	-.102	-.079	.468**	.468**	-.044
	Sig. (2-tailed)							.607	.526	.624	.002	.002	.783
	N						41	41	41	41	41	41	41
Number Quiz	Pearson Correlation							1	.176	.027	.181	.181	.077
	Sig. (2-tailed)								.271	.868	.258	.258	.634
	N							41	41	41	41	41	41
Open Sesame	Pearson Correlation								1	.826**	.480**	.480**	-.057
	Sig. (2-tailed)									.000	.001	.001	.722
	N								41	41	41	41	41
Let's Count	Pearson Correlation									1	.182	.182	-.044
	Sig. (2-tailed)										.256	.256	.783
	N									41	41	41	41
Catch	Pearson Correlation										1	1.000**	-.059
	Sig. (2-tailed)											.000	.714
	N										41	41	41

Table 5.30, continued

Balance	Pearson Correlation	1	-.059
	Sig. (2-tailed)		.714
	N	41	41
Pull	Pearson Correlation		1
	Sig. (2-tailed)		
	N		41

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed).

5.3.4.7 Multiple Regression Analyses for Virtual Game Assessment

Regression Analysis for Language and Communication Skill

A prediction model for language and communication skills with predictor (*Body Quiz*) and dependent variable (*Number Quiz*) produced $F(1,39)=1264.3$, $p<0.001$, $R^2=0.97$ (see Table 5.31 (a) and (b)). *Body Quiz* contributed to this regression model, $\beta=1.055$, $p<0.001$ (see Table 5.31 (c)).

Table 5.31: Multiple regression analysis for *Number Quiz*

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.985[a]	.970	.969	1.516

a. Predictors: (Constant), Body Quiz

(a) Model summary

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	29.055	1	29.055	1264.300	.000[b]
	Residual	.896	39	.023		
	Total	29.951	40			

b. Predictors: (Constant), Body Quiz

(b) ANOVA test

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	-.269	.134		-2.011	.051
	Body Quiz	1.055	.030	.985	35.557	.000

(c) Coefficients test

Regression Analysis for Cognitive Skill

A prediction model with two predictors (*Open Sesame* and *Ball Game*) on problem solving related with object recognition (*Magic Tree*) produced $F(2,38)=6.697$, $p<0.01$, $R^2=0.511$ (see Table 5.32 (a) and (b)). Both the predictors contributed to this multiple regression model at $\beta=0.623$, $p<0.01$ and $\beta=0.385$, $p<0.01$ respectively (see Table 5.32 (c)).

Table 5.32: Multiple regression analysis for *Magic Tree*

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.375[a]	.141	.119	.7915
2	.511[b]	.261	.222	.7439

a. Predictors: (Constant), Open Sesame
b. Predictors: (Constant), Open Sesame, Ball Game

(a) Model summary

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4.004	1	4.004	6.391	.016[b]
	Residual	24.435	39	.627		
	Total	28.439	40			
2	Regression	7.412	2	3.706	6.697	.003[c]
	Residual	21.027	38	.553		
	Total	28.439	40			

b. Predictors: (Constant), Open Sesame
c. Predictors: (Constant), Open Sesame, Ball Game

(b) ANOVA test

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	1.276	.384		3.323	.002
	Open Sesame	.516	.204	.375	2.528	.016
2	(Constant)	-.659	.859		-.767	.448
	Open Sesame	.623	.197	.453	3.168	.003
	Ball Game	.385	.155	.355	2.482	.018

(c) Coefficients test

A prediction model with predictor *Open Sesame* and dependent variable (*Let's Count*) produced $F(1,39)=84.017$, $p<0.001$, $R^2=0.683$ (see Table 5.33 (a) and (b)). *Open Sesame* contributed to this multiple regression model, $\beta=0.356$, $p<0.001$ (see Table 5.33 (c)).

Table 5.33: **Multiple regression analysis for *Let's Count***

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.826[a]	.683	.675	.1503

a. Predictors: (Constant), Open Sesame

(a) Model summary

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.899	1	1.899	84.017	.000[b]
	Residual	.881	39	.023		
	Total	2.780	40			

b. Predictors: (Constant), Open Sesame

(b) ANOVA test

Table 5.33, continued

	Model	Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	2.294	.073		31.448	.000
	Open Sesame	.356	.039	.826	9.166	.000

(c) Coefficients test

Regression Analysis for Psychomotor Skill

A prediction model for psychomotor skill (catch ball skill) with three predictors (*Open Sesame, Keep the Toys,* and *Let's Count*) produced $F(3,37)=23.007$, $p<0.001$, $R^2=0.651$ (see Table 5.34 (a) and (b)). All the predictors contributed significantly to this multiple regression model: *Open Sesame* ($\beta=0.596$, $p<0.001$), *Keep the Toys* ($\beta=0.661$, $p<0.001$), and *Let's Count* ($\beta=-0.865$, $p<0.001$) (see Table 5.34 (c)).

Table 5.34: **Multiple regression analysis for catch ball skill**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.480[a]	.231	.211	.294
2	.708[b]	.501	.474	.240
3	.807[c]	.651	.623	.203

a. Predictors: (Constant), Open Sesame
b. Predictors: (Constant), Open Sesame, Keep the Toys
c. Predictors: (Constant), Open Sesame, Keep the Toys, Let's Count

(a) Model summary

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.014	1	1.014	11.707	.001[b]
	Residual	3.377	39	.087		
	Total	4.390	40			
2	Regression	2.198	2	1.099	19.048	.000[c]
	Residual	2.192	38	.058		
	Total	4.390	40			
3	Regression	2.858	3	.953	23.007	.000[d]
	Residual	1.532	37	.041		
	Total	4.390	40			

b. Predictors: (Constant), Open Sesame
c. Predictors: (Constant), Open Sesame, Keep the Toys
d. Predictors: (Constant), Open Sesame, Keep the Toys, Let's Count

(b) ANOVA test

Table 5.34, continued

	Model	Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.416	.143		2.911	.006
	Open Sesame	.260	.076	.480	3.422	.001
2	(Constant)	-2.868	.734		-3.907	.000
	Open Sesame	.288	.062	.534	4.631	.000
	Keep the Toys	.656	.145	.522	4.531	.000
3	(Constant)	-.906	.793		-1.143	.261
	Open Sesame	.596	.093	1.103	6.383	.000
	Keep the Toys	.661	.123	.526	5.385	.000
	Let's Count	-.865	.217	-.689	-3.993	.000

(c) Coefficients test

5.3 Discussion

This research aimed to investigate the effectiveness of the proposed framework in promoting knowledge transfer to the preschool children in the areas of language and communication, cognitive and psychomotor skill. This study used a quasi-experimental approach with randomised, non-equivalent pretest-posttest control group design. Their performance in the post-tests (*Physical Game Assessment* and *Virtual Game Assessment)* allowed the comparison between the proposed method and the conventional classroom method to be made.

5.3.1 Evaluation of framework

The proposed framework was evaluated through four dimensions: context, learner specification, pedagogic considerations, and mode of representation. This evaluation listed out the criteria to implement GBL in classroom practice such as context, target learner, educational approaches, and system requirement of educational game. It offers help to the effort of embedding games in teaching practice.

The analysis highlights the pedagogic models and approaches that are needed for effective learning. Besides, the learning context can be taken place in both formal (school) and informal (home) setting reinforces learning outcomes. Furthermore, this evaluation can also be used to guide the kindergarten teachers and/or practitioners how to integrate game with curricula, achieve learning objectives and improve learning outcomes.

5.3.2 Teacher Feedback

The involvement of teacher in the entire learning process, started from system design till the evaluation of children's learning, was one of the key success factors of this study. The positive feedback of the teachers on using GBL in classroom practice reveals their high level of acceptance for technology integration and the change in their role. They noticed the benefits of technology in their practice. First, they can ensure the learning objectives are meet through taking the role of advisor in the project team. Second, they have more time to observe the children and assist those who need additional attention and guidance. Third, they can monitor the children's learning progress via games and make adjustment to their teaching method as well as the pace of teaching.

Throughout the intervention program, teachers' observed how the children learned to interact with the system, how they improved, and get used to it. The instructional approach embedded with visual aids, demonstration (scaffolding) and feedback are useful and effective. The proposed system helps them to give compliment and guidance to children instantly. They were motivated and willing to adopt the proposed system in their classrooms.

Overall, approximately 94% of the teachers showed a positive response towards the use of the proposed system as a tool to teach and assess preschool children. They agreed that the system was easy to use and able to assist in teaching and assessing processes. However, two teachers (6%) disagreed on the use of the learning and assessment modules in their teaching. They felt more comfortable with the traditional classroom teaching methods, and were more familiar with the aforementioned methods when compared to the GBL approach. Their low confidence in the usefulness of VLE in teaching preschool children was due to the need for technological knowledge and experience in handling the innovative devices, both of which they lacked. Exposure to innovative technology can help them to understand the trend of technology and the benefits of technology integration, resulting changing in mind. Furthermore, administrative support and technical support training may also help to improve their acceptance of technology integration.

5.3.3 Observation on Children Behaviour

Overall, majority of the children enjoyed the learning with the proposed system, which operated in VLE. All of them were having fun when interacting with the system. They did not realised they were learning or being assessed.

The observation on children learning throughout the intervention program reveals a fact that game can bring changes to behaviour and learning style. GBL as a new learning method has offered them a new learning experience. They showed up voluntarily, felt excited and engaged with the lessons. Besides, this new learning experience also gives positive impact to the daily communication between peers. Children who were shy started to join the lesson voluntarily and talked about their experience with the learning system within and after the lesson.

Although the new learning experience encourages the communication between peers, collaboration learning for preschool children at age 4 is yet to be studied. By considering their level of knowledge and communication skill, guided learning and instructional approach are still the best choice for GBL learning. Children at this age might not able to express themselves effectively and thus increase the challenge in establishing group discussion and collaboration among themselves.

5.3.4 Analysis of Children Performance

5.3.4.1 Pre-test

The collected data was analysed through a normality test. This normality test is important in making statistical inference because many statistical analyses often assume that the sample mean estimator is approximately normally distributed while testing the population mean (Yazici & Yolacan, 2007). Besides, many educational variables such as test score, knowledge, and skill are normally distributed (Bryant, Bradley, Maclean, & Crossland, 1989). The results showed that the sample of population was taken from a normal population based on the normality test on the performance of participated preschool children. The assignment of group also followed a normal distribution.

Overall, girls' performance in pre-test was better than the boys' performance. The results were in line with the developmental research claiming that girls' brains mature earlier than do boys' brains (Gurian & Stevens, 2010). Usually too, girls develop and learn faster than boys at the preschool age. In addition, a girl always reads faster and has a larger vocabulary than a boy at the same age (Gurian & Stevens, 2010). Moreover, girls have a higher mastery of locomotor skills (i.e. run, hop, and jump) in comparison with boys (Hardy, King, Farrell, Macniven, & Howlett, 2010).

5.3.4.2 Analysis of Physical Game Assessment

Overall Performance Analysis

According to descriptive statistics and ANOVA test results, the mean score of *Physical Game Assessment* (post-test) for both the control group and experimental group was improved when compared with the pre-test. However, the children in the experimental group surpassed those who were in the control group in demonstrating a significant difference after attending the intervention program. Many studies have reported that learning with games can improve learning performance (Chuang, 2007; Muis et al., 2015; Shute et al., 2015). Mitchell and Savill-Smith (2004) stated that game can enhance children's cognitive development. Game can also lead to changes in knowledge, attitudes, behaviour, and skills (Ifenthaler et al., 2012). One plausible explanation is that children learn the knowledge and motor skills presented to them through the game activities and the practice increases their understanding with the content knowledge, thus leading to improved learning performance (Hsiao & Chen, 2016).

The analysis was conducted to examine gender differences in learning performance for the intervention program. The analysis showed that the learning gains for boys and girls did not differ significantly. This finding supports the theory that game-based learning (GBL) can be equally effective and motivational for boys and girls (Papastergiou, 2009a).

The analysis of learning performance based on three levels of performance (*Excellent, Average, and Low*) was to evaluate the impact of the intervention program on individual differences. According to the ANCOVA test for the children's performance in three different levels of performance, the experimental group demonstrated significant improvement when compared with the control group. Aunola, Leskinen, Lerkkanen, and Nurmi (2004) suggested that children with different level of performance can also benefit from a different curriculum and methods of instruction. Thus, the findings reveal that the GBL approach assisted the participating children with different levels of performance to improve and achieve a better learning gain. For the control group, the overall mean of post-test ($m_{pretest}$ = 79.42) for children with *Excellent* performance (see Figure 5.21 (a)) was drop when compared with the pre-test ($m_{pretest}$ = 88.60). The possible reasons for this are the scope of post-test is larger than the pre-test and their performance is not consistent due to distraction and emotional issues. Graziano, Reavis, Keane, and Calkins (2007) reported that children's regulation of emotion was positively related to academic achievement.

Analysis of Children's Performance by Areas of Development

From the results, the children's performance differs significantly between groups and level of performance in the specific areas of development, which are language and communication, cognitive, and psychomotor skills. Further analyses revealed that experimental group and control group had significant differences in performance for language and communication and cognitive skill evaluation. Although the difference in performance by level of performance was only significant for language and communication skill, the performance of experimental group, for each level of performance, was higher than the control group in all the areas of development. Our findings are consistent with other recent studies that report language skills to be fundamental to cognitive development (Barac, Bialystok, Castro, & Sanchez, 2014; Marchman & Fernald, 2008; Welsh, Nix, Blair, Bierman, & Nelson, 2010). Merrill (2002) highlighted that learning is facilitated when knowledge is demonstrated to the learners and integrated into their world. Unlike the conventional classroom approach, the experimental group learnt using voice and gesture interaction in a virtual environment under the control and monitoring of a teacher. This approach allowed the children to practice and improve their knowledge through the learning task, which was incorporated with instruction and feedback.

The analysis of children performance for psychomotor skill was not significant between groups and level of performance. Still, the performance of the experimental group, for each level of performance, surpassed the control group. According to the results, children with *Average* and *Low* performances performed better than those with *Excellent* performance in psychomotor skill assessment. This trend also happened to control group. The finding contrasted with studies that report students who have good motor skills usually have better academic performance (Aadland et al., 2017; Ericsson, 2008). However, Wang, Lekhal, Aaro, Holte, and Schjolberg (2014) found that early language performance was not a strong predictor for motor skill especially for young children because development before the age of 3 is different from development after age 3 in aforementioned domains.

Analysis of Children's Performance in Language and Communication Skill Assessment

According to the MANOVA tests and profile plots, there were significant differences in word recognition performance. The experimental group outperformed the control group for all categories of word. Their performance was consistent for words of colour, shape, and number except for body part. All the children in the experimental group scored full marks (total mark is 5 marks) regardless of their level of performance. This result may explain why the differences in performance by level of performance (*Excellent*, *Average*, and *Low*) were only noticeable for the word recognition of number and colour. Besides, the variance in performance for words of shape is small and therefore the difference was not significant.

The variance in the experimental group's performance for shape was small. The performance of the control group was not consistent when examined by level of performance especially for shape. Plausible reasons could be that the development of spatial skill does not align with the development of language skill due to individual differences or developmental trajectory. The learning of shape mostly depends on spatial skill and this skill can be improved over time or through training of intervention program such as virtual interactive learning environment (Cohen & Hegarty, 2014), computer game (Lin & Chen, 2016), and mental rotation task (Meneghetti et al., 2016). This explains why the experimental group performed better than the control group; the effect of intervention program as the VLE improves their spatial skill through voice and gesture interaction with virtual objects.

The children's learning performance in word can be influenced by their familiarity with the object or action (i.e. run, jump, etc.) they need to learn and name (Gray & Brinkley, 2011; Sera, Cole, Oromendia, & Koenig, 2014). The significant difference in performance for word learning demonstrated by the experimental group may suggest that the selection and categorisation of words are suitable for the preschool-aged children and the design of the learning system produce the sense of familiarity with the learning subject. Our findings support the hypothesis that learning words through categorisation can enhance the ability to retain words and their conceptual properties

(Neuman, Newman, & Dwyer, 2011). Moreover, the findings also confirm the appropriateness and level of challenge of the learning activities in delivering content knowledge to the preschool-age children. The use of scaffolding (i.e. visual aids) in the proposed learning system increases children's understanding of the content and thus improves their knowledge and learning gain (Chen & Law, 2016).

The differences in performance for communication skill are only shown in the body part's function assessment (*Q & A Game*) because most of the children in both groups can accurately point out the body part. The outcome reveals that although the children are familiar with body part and are able to identify (point) body part's function, they may not able to communicate or elaborate it. Stiller, Goodman, and Frank (2015) has stated that children who are able to use pointing to show the location of target object might not successfully adjust their communication skill accordingly. The inconsistent performance shown by the control group for the communication skill assessment shows that they lack of opportunity to practice verbal communication. The proposed system was designed to improve children's comprehension of learning materials through voice interactive learning environment, instructional guidance, and instant feedback.

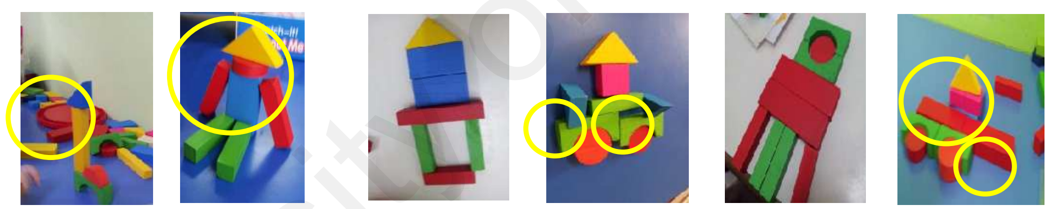
Analysis of Children's Performance in Cognitive Skill Assessment

Building Blocks and *Counting Game* were used to evaluate the decision-making and problem solving skills of preschool children.

Building Blocks consists of three levels of difficulty. Each level contains two types of model: 2D and 3D model. The children need to study the given model, look for the right blocks (correct matching of colour and shape), and construct the model correctly. This process requires them to use analytic skill (study the model), decision-making (choosing the blocks), and psychomotor skill (concentration and hand-eye coordination). Throughout the observation, most of the children have no problem deciding/choosing the blocks to construct the given model. Nonetheless, the performance of control group in this assessment was poor and not consistent with 2D and 3D models when compared to the experimental group. The discrepancy in performance for the control group most probably was caused by their visual/spatial weakness.

(a) 1A (b) 1B (c) 2A (d) 2B (e) 3A (f) 3B

Model construction



(g) 1A (h) 1B (i) 2A (j) 2B (k) 3A (l) 3B

Children's construction with mistake

Figure 5.33: Mistakes found in children's construction

Building blocks challenge the children with spatial thinking and visual skill. Through observation, children made different types of mistakes in their model construction. Figures 5.33 (a) to (f) are the models that the children were required to build whereas Figures 5.33 (g) to (l) are the mistakes spotted in some of their constructions. Verdine et al. (2014) had analysed the issues found in copying block designs for young children that related with dimensions (vertical, rotation, translation) of spatial thinking. Figures 5.33 (h), (i), and (k) are those mistakes related to vertical dimension (number of level for the model to be constructed). The problem associated with rotation dimension (orientation) is the misplacement of a block relative to the block it sits on. For example, the blue triangle in Figures 5.33 (g) and (j) was in the wrong orientation, which is highlighted with the yellow circle. Figure 5.33 (l) is the example of a translation dimension's mistake (incorrect placement of a block relative to the position of other blocks).

Martin-Dorta et al. (2014) reported that learning through 3D virtual interactive environment can facilitate the development of spatial ability. Besides, the user-friendly and intuitive interface may also offer more learning opportunities in compensating the visual weakness via the 3D simulation and object manipulation (Wang, Wu, & Hsu, 2017). Study of Merchant et al. (2013) and (Lee & Wong, 2014) reported that students improved their spatial skill via the interaction with 3D objects compared with 2D images such as textbook or whiteboard drawing. This could be one of the reasons that explain the outstanding performance of experimental group in building block activities. Other factors such as individual differences, interest of game, and attention may also affect children performance.

Counting Game assesses the preschool children's cognitive skills associated with counting. The children need to have knowledge of number, rote memorization (number in ascending order), decision-making (repeat the counting or not), and fine motor skill (counting/pointing). Overall, the performance of the experimental group was better than the control group. The variance in performance for the experimental group is relatively small ($SD < 0.35$) when compared with the control group ($0.5 < SD < 1.62$) for three levels of performance.

Based on observation, most of the children will repeat their counting to confirm their answer. This action reveals that they are able to decide whether there is a need for them to repeat the counting. For example, if the question involves a small quantity of object (<5), they will choose to say the answer immediately after the counting. For question that involves big amount of object (>5), there is a high probability they will count for a second time to confirm the final answer. Another possible reason could be the training provided by the teacher. The teacher decides and controls the frequency and duration of practice for all the children via his/her observation and understanding of the children's learning progress, regardless of the learning context. With proper instruction and teacher's control, gaming activities can boost the performance of children's number skill (Obersteiner, Reiss, & Ufer, 2013; Whyte & Bull, 2008).

Analysis of Children's Performance in Psychomotor Skill Assessment

Ball Skills is used to evaluate the catch, throw, and pass (kick) ball skill whereas *Leg Game* comprises the test on balance, jumping, running, and hopping. Overall, the differences in performance for these two assessments for gender and level of performance were not significant except for groups. However, significant differences were found in group's performance for body balance (one leg stand), jumping (jump forward), and kicking (left kick) after further analysis for each motor skill was conducted. Still, the differences in motor performance among group was small (mean difference<0.1). The results are in line with children motor competence studies that gross motor skills are interrelated (Vedul-Kjelsås, Sigmundsson, Stensdotter, & Haga, 2012). In this study, children who can do the running mostly have no problem performing the ball skill and hopping.

Liao and Hwang (2003) reported that balance skill is highly correlated with gross motor skill such as jumping (Hrysomallis, McLaughlin, & Goodman, 2006) and kicking (Tracey et al., 2012). This explains differences found in the analysis of children motor skills (balance, jumping, and kicking). The differences in body balance may be caused by the developmental phases and will improve with increasing age (Figura, Cama, Capranica, Guidetti, & Pulejo, 1991; Ozbar, Mengutay, Karacabey, & Sevindi, 2016). In addition, regular practice of particular motor skill will also improve overall performance (Lopes, Rodrigues, Maia, & Malina, 2011).

5.3.4.3 Analysis of Virtual Game Assessment

Overall Performance Analysis

Based on the two-way ANOVA test, there was no significant difference on the effect of gender and the level of performance as well as the interaction of these two effects. A two-way MANOVA test was then carried out to examine the preschool children's overall performance in all the three assessments which include pre-test, *Physical Game Assessment*, and *Virtual Game Assessment*. The mean score for post-tests (*Physical Game Assessment* and *Virtual Game Assessment*) as well as the interaction between post-tests' performance and the level of performance were found to be significantly different. Boys with *Low* performance outperformed the boys with *Average* performance whereas girls with *Low* performance surpassed those girls with *Excellent* and *Average* performances in *Virtual Game Assessment*.

The results are similar to the findings of other research that have used the gesture-based virtual learning environment (VLE) approach (Homer et al., 2014; Hsiao & Chen, 2016; Huber et al., 2016). One plausible explanation is that the use of voice and gesture interaction in VLE triggers pre-schoolers' interest in learning. They learn the knowledge and motor skills presented to them through the game activities and achieve a flow state that improves their learning performance (Hsiao & Chen, 2016). The improvement in post-tests provides evidence of knowledge transfer in the context of physical context (computer game assessment and classroom assessment) and modality (game, oral test, and demonstration) (Barnett & Ceci, 2002).

Analysis of Children's Performance by Areas of Development

According to the results, the differences in children's performance were only spotted in language and communication and psychomotor skills by the level of performance. Our findings are consistent with other recent studies that utilise the intuitive interface (voice and gesture-based interaction) to promote learning (Muis et al., 2015; Pilegard & Mayer, 2016) and motor skill development (Barnett et al., 2012; Vernadakis et al., 2015b) or both (Hsiao & Chen, 2016). Although the preschool children with different level of performance did not differ in cognitive skill assessment, their achievement gap was reduced. The achievement gap can be closed via an effective GBL approach (Hung, Young, & Lin, 2015).

Analysis of Children's Performance in Language and Communication Assessment

Overall, children with *Excellent* and *Average* performances consistently demonstrated good performance in all the assessments. The children (boys and girls) with *Low* performance outperformed the children with *Excellent* and *Average* performance in the language and communication assessment. Again, the outcome support the findings of GBL studies where the performance gap can be improved through effective instructional approach and reinforcement on skill and knowledge learning (Bai, Pan, Hirumi, & Kebritchi, 2012; Hung et al., 2015; Kebritchi et al., 2010).

Analysis of Children's Performance in Cognitive Skill Assessment

Overall, all the children performed well in assessment related to decision-making. Their performance for problem solving assessment was moderate and varied by level of performance. The children demonstrated good decision-making skills but they still need more practice to improve their problem solving skills. Problem solving is a complicated process and requires complex thinking skills (i.e. reasoning skill, information gathering and processing skill, and decision-making skill) (Kim et al., 2009; Shih et al., 2010). Through the presentation and manipulation of a problem, game can actually assist the students in improving their decision-making and problem solving skills (Shih et al., 2010). However, children may have different ways of thinking and strategies to solve a problem due to personal experience, prior knowledge, and understanding of a problem (Hwang, Hung, & Chen, 2014; Webster-Stratton & Reid, 2004).To improve the children's ability in analysing a problem and finding the right solution, it is necessary to enhance the instruction and feedback for the problem solving activities.

Analysis of Children's Performance in Psychomotor Skill Assessment

Overall all, the children have no problem performing the motor skills (*Run*, *Kick*, and *Hop*, *Balance*, *Jump*, *Catch*, *Throw*, *Push*, and *Pull*. Our findings show that GBL is not only an effective approach for learning but also facilitating psychomotor skill development. Girls with *Low* performance had demonstrated a great improvement in all the psychomotor skill assessments. As mentioned earlier, girls develop and learn faster than boys at preschool age due to developmental chronology (Gurian & Stevens, 2010). Therefore, they have higher mastery of locomotor skills in comparison with boys (Hardy et al., 2010). Another possible reason that explains why those children who have *Low* performance can achieve significant improvement is that they benefit from the gesture recognition function of the proposed learning system. The system examines their movement/motor skill and gives feedback to them. Those who perform correctly will receive compliments to make them confident; in contrast, an encouragement message informs them of their mistake and allows them to correct their mistake. The system asks children to repeat the movement until they get it right. The demonstration (scaffolding), instruction and feedback allow the children with poor motor skills to improve via sufficient training for a particular motor skill and mastery of motor skills.

Correlation Analyses by Children Development Areas

In general, children development covers the areas of language and communication, cognitive, and psychomotor skills. All the aforementioned areas of children development were interrelated at different degrees of correlation. These findings are also consistent with the current research on children development (Houwen, Visser, van der Putten, & Vlaskamp, 2016).

Overall, cognitive skills correlated with language and communication skill and psychomotor skill at weak-to-moderate level ($0.1 < r < 0.5$) for *Physical Game Assessment*. On the other hands, in the *Virtual Game Assessment*, moderate correlation ($0.3 < r < 0.5$) was found for the aforementioned areas of development. As both the language and communication and psychomotor skill required cognitive processing, these results are in-line with other related studies (Goldin-Meadow et al., 2014; Westendorp et al., 2014).

The correlation between language and communication and psychomotor skills for *Physical Game Assessment* is weak whereas no significant correlation was found in *Virtual Game Assessment*. This result is in line with the finding that prediction for language and motor performance is weak ($r < 0.3$) especially for young children (M. V. Wang et al., 2014) due to the differences in development.

Regression Analyses by Children Development Areas

Multiple regression analyses were conducted to determine the association between specific areas of development. Several prediction models were carried out to examine the contribution of predictors (assessment) to the assessed skill (dependent variable).

Regression Analysis for Language and Communication Skill

Early language and communication skill plays an important role in the development of children's social skills. Vocabulary learning builds the foundation for learning a language and developing the social skills (Carter & Mccarthy, 2014). The learning of vocabulary can begin with familiar objects and its properties such as body parts, colour, shape, and number.

For *Physical Game Assessment*, the regression analysis for language and communication skill shows that the word learning of number and body part is significantly interrelated with each other. On the other hand, similar results were gained for *Virtual Game Assessment* where only the vocabulary of number was intertwined with the vocabulary of body part. The possible reason for this is that knowledge of body part is strongly related to number and its function. All the body parts can be counted, for example, eyes, hands, and fingers. The use of number in communicating the body part and its function in children daily communication such as "*I have two eyes*", "*I eat with two hands*", and etc., is quite common.Thus, the early language and communication development should start with the learning of surrounding objects, people, and environment in the children's daily life and communication (Buckley, 2012).

Regression Analysis for Cognitive Skill

The regression analysis for cognitive skill in *Physical Game Assessment* and *Virtual Game Assessment* produces similar results that problem solving skill is interrelated with decision-making skill. Both types of assessments involve the evaluation of decision-making and problem solving skills. For *Physical Game Assessment*, *Building Blocks* and *Counting Game* evaluate both the decision-making and the problem solving skills. According to the result, building block skill has significant association with counting skill and the significant predictor for this association is the 2D model building block skill. The finding is consistent with those studies that recommend the use of building block game to promote pre-schoolers' learning of mathematics/number knowledge of building block game, to promote their learning of mathematics/number knowledge (Clements & Sarama, 2007; Sarama & Clements, 2004; Verdine et al., 2014). Apart from the counting skills, building block skill requires spatial and analytic skill in order to complete a different model of construction. These skills are important in building the model correctly and in reducing mistakes in understanding the dimension and the structure of model.

In *Virtual Game Assessment*, there are six assessments for cognitive skills, which are problem solving (*Magic Tree*, *Fix Me*, *Open Sesame*, and*Let's Count*) and decision-making (*Ball Game* and *Keep the Toys*). Based on the results, only the regression models used to predict *Magic Tree* and *Let's Count* have significant association with other cognitive skill assessment. *Magic Tree* (body part) was found to be related with *Open Sesame* (number) and *Ball Game* (colour) whereas *Let's Count* (number) was related to *Open Sesame* (number). Generally, problem solving is a process to study a problem and develop a solution based on available choices. The findings are in line with the idea that the fundamental concept of problem solving needs several cognitive skills like reasoning, information processing and decision-making to solve a problem (Kim et al., 2009; Shih et al., 2010). Again, the findings also confirm the mutual relationship between body part and number. Although the regression result for *Let's Count* (number) did not involve any assessment focused on decision-making skill, *Open Sesame* (number) did require the children to decide on which number was to be pressed.

Regression Analysis for Language and Communication and Cognitive Skills

For *Physical Game Assessment*, the prediction model with predictors of shape (*Card Game*), body part (*Card Game*), and body part's function (*Q & A Game*) was found to be associated significantly with the performance of *Building Block*. Another prediction model with predictors of number (*Card Game*), body part (*Card Game*), and body part's function (*Q & A Game*) was also found to be significantly associated with the performance of *Counting Game*. In *Virtual Game Assessment*, there is no prediction model found to have the association between language and communication and cognitive skill since the correlational result shows none of the aforementioned areas was correlated. However, all the cognitive skill assessments required the prior knowledge with body part, colour, shape, and number. Good performance in language and communication skill assessment does not ensure similar achievement in cognitive skill assessment. The assessments for language and communication skill evaluate vocabulary knowledge and object recognition skill in a straightforward manner whereas cognitive skill assessments require the use of complex thinking skills such as information processing, problem analysis, and decision-making in addition to vocabulary knowledge. The unfamiliarity with computer game assessment and inconsistent performance could be the reasons why the aforementioned association is hardly found. Further study on children's problem solving model and broader scope of language learning may allow more effective strategies to be discovered for evaluating the cognitive and language skill of preschool children via virtual game assessment.

Earlier discussion had mentioned that *Building Block* was associated with *Counting Game*. This association can be seen from the use of same predictors, which are body part and body part's function in the prediction model. The learning of body part involves number (number of body part) and shape recognition (shape of body part). As discussed earlier, body part and number knowledge are interrelated as all body parts can be counted. The knowledge of body part and the ability to recognise the correct body part are closely related to children's spatial skill (recognition of shape). Many studies encourage the use of *Building Block* to promote pre-schoolers' learning of mathematics/number knowledge because it trains the children in spatial skill and counting (Clements & Sarama, 2007; Sarama & Clements, 2004; Verdine et al., 2014). The regression results give evidence for the association of learning body part, shape, and number for preschool children. Moreover, Weisleder and Fernald (2013) had stated the importance of cognitive skills in facilitating language learning performance.

Regression Analysis for Psychomotor Skill

For *Physical Game Assessment*, the prediction model with predictors of catch ball skill, jumping, and kicking found associated significantly with the body balance skill. In *Virtual Game Assessment*, there is no association among the psychomotor skills although the correlational result shows that the catch ball skill and body balance was perfectly correlated. The reason for this result is that the score for several psychomotor skills is constant, where the variance equals to 0 (see Appendix G). All the children have same mark for the assessment of run, kick, hop, push, and pull after performing the corresponding skill correctly (0 for wrong movement and 1 for correct movement).

The result shows that the children have developed several psychomotor motor skills and pass the milestone of development and movement for a child at age 4 which include jumping, hopping, balancing and catching ball (Green-Hernandez et al., 2001).

Regression Analysis for Cognitive and Psychomotor Skills

For *Physical Game Assessment*, the prediction model with catch ball skill as predictor found associated significantly with the building blocks skill (problem solving). In *Virtual Game Assessment*, the prediction model with multiple predictors, *Open Sesame* (problem solving), *Keep the Toys* (decision-making) and *Let's Count* (problem solving), associated significantly with the catch ball skill.

In general, motor and cognitive development is fundamentally interrelated (Diamond, 2000). The acquisition of psychomotor skills also requires the mastery of cognitive concepts such as catching a ball based on a given condition or throwing a ball with target (Thomas, 2004). The regression analyses for the two post-tests give evidence for the association between psychomotor and cognitive skills. The result infers the importance of physical development in early childhood for building motor skills, physical health and cognitive learning (Liddle & Yorke, 2004).

Language and Communication and Psychomotor Skills

No prediction model was found to be statistically significant for the correlation between language and communication and psychomotor skills for both *Physical Game Assessment* and *Virtual Game Assessment*. The links between motor skill and language development are not strong and limited to specific motor skills (Alcock & Krawczyk, 2010). One plausible reason is that the assessments may partially involve these two skills at the same time resulting in poor correlation between the two skills. Based on the finding, the development of young children in the aforementioned areas was hard to predict especially after the age of 3 (Wang et al., 2014). Further studies are needed to better understand the influence of language and communication skill on the development of psychomotor skill and the degree of correlation through a broader scope of assessment and analysis.

5.4 Summary

This purpose of this study was twofold. First, the study examined the effectiveness of the proposed framework in assisting the teachers in teaching and assessing the preschool children. Then, the effectiveness of the proposed framework for improving preschool children's learning in the areas of language and communication, cognitive, and psychomotor development, was investigated.

A system, which comprised learning modules and assessment modules, was proposed to accomplish the aforementioned goals. The system was tested on speech recognition, gesture recognition and system integration testing. The system testing was successfully run for voice recognition and validation of the movement for head, hand, and leg. Lastly, the system integration testing, which includes the functionality of learning modules, assessment modules and reporting, was completed and the fundamental requirements of the proposed system were met.

The evaluation of framework shed the light on how to integrate game with pedagogy approaches to enhance learning. The analysis also ensures the kindergarten teachers and/or practitioners on how to integrate game with curricula, achieve learning objectives and improve learning outcomes. Besides, the learning context can be taken place in both formal (school) and informal (home) setting reinforces learning outcomes.

The involvement of teacher in the entire learning process increases their acceptance for technology integration and the change in their role. Besides, they also noticed the benefits of technology in their practice. Based on the survey of teachers' feedback, approximately 94% of the teachers showed a positive response for the use of the proposed system as a tool to teach and assess the preschool children. The proposed system uses VLE to teach the learning materials to the preschool children. The voice recognition feature assists the teacher in teaching word pronunciation by validating the children's pronunciation. Besides, the gesture recognition function, which verifies the performed movement, helps the teacher in examining the children's psychomotor skill. In addition, the use of instruction, scaffolding (visual aids and demonstration) and feedback supports the teacher in teaching and improves preschool children's learning.

The observation on children learning supports the theory that game can bring changes to behaviour and learning style. Overall, majority of the children enjoyed the learning with GBL in VLE and engaged with the lessons. GBL offers them a new learning experience and gives positive impact to the daily communication between peers.

Two assessments, which are *Physical Game Assessment* and *Virtual Game Assessment*, were used to evaluate the children learning performance with the proposed system. Both assessments examine the children learning performance in the areas of language and communication, cognitive and psychomotor skills through different evaluation approaches. These two assessments allow the teacher to measure their knowledge and the mastery level of skills in real life and virtual reality context. In relation to one type of assessment only (physical test), virtual interactive game provides the teacher with additional information on the children's knowledge and skill development. In summary, the proposed system offers the teacher a tool to teach and assess the preschool children.

The control group's children only sat for *Physical Game Assessment* whereas the experimental group's children took both assessments. The experimental group excelled in both assessments. Their outstanding improvement in the area of language and communication, cognitive, and psychomotor development gives evidence of the effect of the proposed system. One plausible explanation is that they learned the knowledge and motor skills presented to them via simulation and demonstration in VLE. The practice and feedback has increased their understanding of the content knowledge and mastery of skills, thus improving their learning performance. No significant differences found for gender and the results support the theory that GBL can be equally effective and motivational for boys and girls.

The analysis of learning performance based on the three levels of performance (*Excellent, Average, and Low*) revealed that those who learned with the GBL approach achieved a great improvement in their learning gain and the achievement gap among the children was reduced. One possible reason for this is the use of voice and gesture interaction in VLE triggered the pre-schoolers' interest of learning. They obtained knowledge and developed motor skills through engagement with the game activities. The continuous practice with the proposed system boosted their learning performance.

The examination of preschool children's performance by the areas of development (language and communication, cognitive, and psychomotor skills) showed that the children in experimental group outperformed the children in control group for all the areas of development. The good performance of the experimental group implies the proposed system improve their learning and comprehension of learning materials.

The correlational analyses show that the development of language and communication, cognitive, and psychomotor skills were interrelated at different degrees of correlation. The regression analysis for language and communication skill shows that the vocabulary of number is intertwined with the vocabulary of body part. In addition, this association was also found in those assessments related with cognitive skill. The possible reason is that knowledge of body part is strongly related with number and its function. The regression analysis for cognitive and psychomotor skill supports that the acquisition of psychomotor skills also requires the mastery of cognitive concepts and thus shows that these two areas are closely intertwined. The result infers the importance of psychomotor development in early childhood and its influence on cognitive development.

Overall, the proposed system can assist teachers in teaching and assessing the preschool children. In addition, the proposed system also improved preschool children's learning in the areas of language and communication, cognitive, and psychomotor skills. This can be seen through comparisons of the performances of the children in the control group and those of the experimental group. Moreover, the intervention program benefited both boys and girls in the experimental group and reduced the achievement gap among the children. In addition, the proposed system can be used as a learning and evaluation tool for preschool-aged children as it achieved the proposed learning objectives and matched the knowledge level of preschool children.

CHAPTER 6: CONCLUSION

6.1 Achievement of the Research Objectives

The following are the objectives of research:

O1. To propose a game-based learning (GBL) framework for selected preschools to

- assist teachers in teaching and assessing preschool children.
- improve preschool children's learning in terms of language and communication, cognitive, and psychomotor development.

O2. To design a virtual learning environment (VLE) based on the proposed framework.

O3. To evaluate the ability and capacity of the proposed framework to

- assist teachers in teaching and assessing preschool children.
- improve preschool children's learning in terms of language and communication, cognitive, and psychomotor development.

The details of the approaches used to achieve the first objective are as below:

i. A GBL framework is proposed to accomplish the first objective in order to assist teachers in the process of teaching and evaluation and improve the preschool children's learning. In the proposed framework, the teacher's role is enhanced for the areas of learning, instruction, and assessment. This is achieved by involving the teacher in the process of system design and children's learning and evaluation.

ii. A survey is used to identify the scope of the proposed system for age 4 children. Based on the survey result, a system prototype that operated in the VLE was developed.

iii. A learning system, namely *myKinderLand*, was developed using the VLE based on the proposed framework. The system consists of learning modules and assessment modules. In learning modules, demonstration and instruction are used to teach learning materials to the preschool children. The intuitive interaction (voice and gesture) feature allows them to practice the language and communication, cognitive and psychomotor skills in the VLE. Instant feedback is given to notify the children of their performances; compliments are used to praise the children for giving a correct response and messages of encouragement are used for incorrect responses.

To achieve the second objective, a virtual learning environment is developed based on the proposed framework. A survey was conducted to collect teacher feedback on the system prototype. The details of the approaches and outcomes are as follows:

i. After the scope of the proposed system was agreed upon by the participating preschools, a system prototype was developed to get feedback from the teachers regarding the appropriateness of the design and content presentation.

ii. A survey was used to examine the teachers' opinion on the usability of the system prototype. Based on their feedback and comments, the system prototype was revised and integrated into a workable system using the VLE.

iii. The proposed system consists of learning and assessment modules. The learning modules consist of three sub-modules (*Learn with Fun*, *Move Your Body*, and *Mind Games*) that are used to improve the preschool students' learning in terms of the development of language and communication, cognitive and psychomotor skills. The assessment modules comprise two types of assessments: *Virtual Game Assessment* and *Physical Game Assessment*. *Virtual Game Assessment* examines the preschool children's learning outcomes via *Body Journey*, *Colour World*, *House of Shape*, *Number Hut*, and *Treasure Hunt* whereas *Physical Game Assessment* assesses their language and communication, cognitive and psychomotor skills through classroom games.

iv. Systems testing on voice and gesture recognition together with system integration testing were conducted to ensure the proposed system fulfilled the specified requirements as a learning and assessment tools for 4 year old children.

An intervention program based on the proposed system was conducted at the participating preschools to accomplish the third objective. The proposed system was able to assist the teachers in teaching and assessing the preschool children via VLE. The approaches and outcome are as described below:-

i. An intervention program was conducted at the selected preschools. 84 preschool children took part in the intervention program for 4 weeks. The intervention program consisted of a pre-test, learning session, and post-tests.

ii. Firstly, the enrolled preschool children were given a pre-test. Their pre-test were graded based on three levels of performance (*Low*, *Average*, and *Excellent*) and the children were randomly divided into control group and experimental group. The control group followed the normal classroom lesson whilst the experimental group learnt with the proposed system. The teacher took the role of facilitator throughout the intervention program and controlled the time spent on each exercise in the modules based on the children's learning performances. It was observed that all the children in the experimental group demonstrated great motivation to learn with the proposed system.

iii. After complete the learning session, the control group sat for the Physical *Game Assessment* whilst the experimental group took both the *Physical Game Assessment* and *Virtual Game Assessment*. The proposed system was able to assist the teacher in evaluating the preschool children and generating the report for their progress through the assessment modules. Most of the participated children enjoyed the assessment activities as a form of play and were willing to complete and repeat the activities.

iv. The collected results were studied and analysed. The results show that the proposed system improve preschool children' learning in terms of language and communication, cognitive and psychomotor skills development.

6.2 Contributions of the Study

This study makes several contributions, as:

i. A GBL framework with interactive VLE for preschool children,

ii. A tool for assisting the teacher in teaching and assessing preschool children, and

iii. A program to improve preschool children's learning

6.2.1 A GBL Framework with Interactive VLE for Preschool Learning

The proposed GBL framework emphasises the aligning of learning, instruction, and assessment. An interactive VLE system was created based on the proposed framework. The VLE conveyed the learning materials to the preschool children in simulated realistic context (real world objects and characters). The pairing of the educational content with game features aimed to ease and improve preschool children's learning through voice and gesture interaction. The learning activities have been coupled with direct instruction and instant feedback, to guide the learning of word pronunciation and development of psychomotor skills. To facilitate learning, the proposed system applied three approaches - scaffolding, imitation, and trial-and-error, to assist the preschool children in comprehending the learning materials. Furthermore, a game-based assessment was designed to evaluate the preschool children in language and communication, cognitive, and psychomotor skills via an adventurous game in a fantasy context. The use of fantasy context and characters aimed to evaluate the transfer of knowledge of the preschool children in a context that is different with the learning context (realistic context).

The proposed framework aimed to enhance the teacher's role in the process of teaching and learning. The proposed system covered the learning areas required by the teacher as well as the scope and the appropriateness of learning materials for preschool children. The mapping of learning materials onto the respective learning modules eased the teaching of specific areas of learning. For example, *Learn with Fun* focuses on the development of language and communication skills, *Move Your Body* conveys the psychomotor elements to preschool children, and *Mind Games* fosters the development of cognitive and psychomotor skills. In addition, the direct instruction and feedback incorporated in the VLE assist the teacher in teaching through simple and straightforward manner. The system feedback not only allows the teacher to understand the children's learning progress but also helps the preschool children to improve from their mistakes. In addition, the VLE also uses the menu to make it easy for the teacher to select the learning materials for teaching and revision purposes. The assessment modules, which are comprised of *Body Journey*, *Colour World*, *House of Shape*, *Number Hut*, and *Treasure Hunt*, are to evaluate the preschool children in the areas of language and communication, cognitive, and psychomotor skills.

The proposed framework also aimed to improve the preschool children's learning in terms of the language and communication, cognitive, and psychomotor development through voice- and gesture-based interaction. The VLE allowed the preschool children to explore and learn in realistic contexts that closely represent real-life objects and environment (high fidelity). Moreover, the proposed system also offered a natural form of control and object manipulation to enhance the children's learning experience. In addition, the scaffolding function, through visual aids and demonstration, helped the preschool children better understand the learning materials. The use of the imitation approach allowed the preschool children to self-examine their performed movements. The feature of trial-and-error permitted them to try their solutions until the correct answer were found. All these features increased their understanding with the learning materials and improved their learning performances.

The evaluation of proposed framework helps kindergarten teachers and/or practitioners to embed games in teaching practice. It highlights the pedagogic models and approaches that are needed for effective learning. Besides, this evaluation can also provide guidance on how to integrate game with curricula, achieve learning objectives and improve learning outcomes.

6.2.2 A Tool for Assisting the Teacher in Teaching and Assessing Preschool Children

The proposed system allows the teacher to teach and assess the preschool children via VLE. The learning materials are organised into individual modules and classified by category. There are three learning modules: *Learn with Fun* (language and communication skills), *Move Your Body* (psychomotor skills), and *Mind Games* (exercises for cognitive and psychomotor skills). Each module consists of sub-modules that each delivers corresponding knowledge or skills. For example, *Learn with Fun* has four sub-modules, which are *Body Part*, *Colour*, *Shape* and *Number*, and teaches the words related with body part, colour, shape, and number, respectively. The menu-based navigation function embedded in every module reduces the effort needed by the teacher when searching for learning materials and teaching of particular knowledge or skills. Apart from navigation, the teacher can also terminate the program at any time if the children are reluctant to continue learning due to concentration and emotional problems. The proposed system incorporates visual aids and demonstration to assist the teacher to teach the preschool children and improve their understanding of the learning materials. In addition, corrective feedback to children helps the teacher better understand the learning pace of each child. This feature also reduces the effort the teacher needs to take to validate the children's performance as it gives compliments for every correct response, and encouragement for every incorrect response. In the case of the latter, the system also provides the opportunity for the child to repeat the question until it is successfully completed.

The proposed framework includes two types of assessment: *Physical Game Assessment* and *Virtual Game Assessment*. The assessment modules are used for evaluating language and communication, cognitive, and psychomotor development of the learner. *Physical Game Assessment* helps the teacher to evaluate the preschool children's learning outcomes via classroom games whereas *Virtual Game Assessment* is done via the VLE. These two assessments are conducted in two different contexts via different games.

The *Physical Game Assessment* allows the teacher to examine the progress of learning and the ability of a child to form a connection to the real world situation. Besides this, the teacher is able to observe the preschool children in cognitive and psychomotor development. In contrast, the *Virtual Game Assessment* helps the teacher assess the children's abilities in applying the learned knowledge and skills in a fantasy context. This assessment allows the teacher to observe how a child processes multimedia information and solve the given problem or question. The proposed system also uses different approaches to evaluate the preschool children's learning performance, e.g., question and answer, puzzle, and games. The tremendous performance demonstrated in the aforementioned assessments showed that there was a transfer of knowledge in the children in the experimental group across modalities (different assessment methods).

The reporting feature simplifies the effort needed by the teacher to record and prepare the learning performance record. Three report cards, which cover the areas of language and communication, cognitive, and psychomotor skills, are generated for each child. These reports help the teacher to identify for each child, the areas that require improvement, and explain his current progress of learning and development to the parent.

After completion of the intervention program, 32 teachers who participated were interviewed individually about their acceptance of GBL for preschool learning. 30 out of 32 (93.75%) teachers were satisfied with the proposed system and were willing to adopt it for teaching and assessing purposes. Before the execution of the intervention program, 8 teachers were reluctant to use GBL. After participating in the intervention program, 6 of them were encouraged to adopt GBL for children learning. However, there were still 2 teachers who felt hesitant to integrate GBL in their classrooms. They were not convinced of the usefulness of computer games in teaching and assessing preschool children. They were more familiar and comfortable with traditional teaching and assessment methods as compared to the GBL approach.

The proposed framework offers the teachers an opportunity to get involved in the entire learning process, started from system design till the children's evaluation. They experienced the benefits of using GBL in their classroom practice resulting changes in their mind. They were motivated, willing to adopt the proposed system in their classrooms, and accept the change in their role.

6.2.3 A Program to improve Preschool Children's Learning

The proposed system brings changes to preschool children's behaviour and learning style. It offers them a new learning experience and also gives positive impact to their daily communication. The interactive VLE allows the children to enjoy the learning and having fun when interacting with the system.

The proposed system improved the preschool children's learning in the areas of language and communication, cognitive and psychomotor skills development. The overall performance shows 47.74% improvement in the post-test when compared with pre-test (see Figure 5.20). The outstanding performance demonstrated by the experimental group's children in *Physical Game Assessment* answers the concern as to whether the children can apply the knowledge and skills learned in the VLE to the reality context. In addition, the children's performance in *Virtual Game Assessment* gave proof of their ability to apply learned knowledge and skills in a fantasy context. Their excellent performance shows evidence of the transfer of knowledge via VLE.

6.2.3.1 Language and Communication Development

The experimental group children, who learned using the proposed system, recorded at least 45% improvement in language and communication skill when compared with the control group children. The outstanding performance of the experimental group in language and communication assessments is evidence for the effectiveness of the proposed system in improving children's language and communication skills.

The proposed system delivers the learning materials to the preschool children in a voice-based interactive VLE via *Learn with Fun* module. *Learn with Fun* uses the learning model (learn→practice→feedback) to improve the preschool children's word learning performance. This was discussed in Section 4.2.2. The *Body Part*, *Colour*, *Shape* and *Number* modules, grouped under the *Learn with Fun* module, teach the preschool children about words and knowledge related to body part, colour, shape, and number, respectively. The results suggest that the proposed system improved their understanding of the learning material. In addition, increases in vocabulary and understanding of the words improved their communication skills.

The regression analysis for language and communication skill assessments shows that learning of words related to numbers is intertwined with the learning of words for body parts. This finding suggests that early language development can begin with the learning of body parts and then be expanded to incorporate number, colour, shape and other categories of words that can connect with the prior knowledge of a child.

6.2.3.2 Cognitive Development

Overall, the children in the experimental group demonstrated approximately 20% improvement better than the control group in the cognitive skill assessments, which involved complex thinking skills such as memorising/recognition, decision-making, and problem solving skills.

Mind Games was designed to assist preschool children in developing recognition/memorisation, decision-making and problem solving skills via the transfer model (process→plan→react→feedback) explained in section 4.2.2. *Mind Games* uses two sub-modules, *Make Your Choice* and *Can You Do This?*, to provide practice on the aforementioned cognitive skills. *Colour Brush, Sticker Game, Catch a Ball,* and *Throw a Ball* grouped under *Make Your Choice* module train preschool children on colour and shape recognition, decision-making, and psychomotor skills. *Can You Do This?* uses *Catch the Bubble*, *Magic Box*, *Move It*, and *Get It* to strengthen their body part and number recognition, as well as problem solving and psychomotor skills.

Based on the transfer model, the preschool children are required to understand the information/instruction given in an exercise (process). For decision-making exercises, they have to make a choice and remember their choice (plan). After that, they have to follow instructions to complete the exercise based on their choice (react). On the other hand, the problem solving exercise trains the preschool children to analyse the given information, find the answer/solution, and solve the problem using the required psychomotor skills

The accuracy of the children in the experimental group in completing the *Building Blocks* assessment indicates that they had developed all the aforementioned cognitive skills. In addition, they also demonstrated the spatial skills related with dimensions (vertical, rotation, translation). However, the children in the control group had not yet developed this skill. This suggests that the learning in VLE and interaction/manipulation with the virtual object improved children's spatial skills related with dimensions. In addition, their problem-solving and recognition skills associated with colour and shape were also improved.

In *Counting Game*, the children were required to count the quantity of objects of a certain kind. Most of the experimental group's children repeat their counting to confirm their answer, especially for questions that involve a large number of objects (>5) based on the observation. This result suggests that those who learnt with the proposed system have demonstrated improvement in their problem-solving skill and in the ability to make decisions by considering the need of the situation.

Overall, the performance of experimental group was relatively better and the variance in performance was smaller when compared with the control group. This result implies that the proposed system has successfully reduced the achievement gap between the children. In conclusion, based on the analysis of the results and observation, the children in the experimental group developed problem-solving, decision-making, and memorising/recognising skills at different levels of mastery.

6.2.3.3 Psychomotor Development

The children in the experimental group demonstrated 5-14% (varied by level of performance) improvement better than the control group in the psychomotor skill assessments. The outstanding performances of experimental group in psychomotor skill assessments provide evidence of the effectiveness of the proposed system in improving children's psychomotor skills.

The effect of the intervention program in developing psychomotor skills is proven by the excellent performance of the experimental group's children in psychomotor skill assessments for both types of assessments. Our findings show that the proposed system is not only an effective approach for learning but also for facilitating psychomotor skill development. *Move Your Body* conveys the psychomotor elements to the preschool children via gesture-based interactive VLE. *Move Your Body* uses the learning model similar with the *Learn with Fun* module to improve the preschool children's psychomotor skill learning performance. The *Warm Up, Body Balance, Hands,* and *Legs* modules, grouped under the *Move Your Body* module, teach the preschool children psychomotor skills associated with body balance, hands, and legs. They have to perform the movement demonstrated by the virtual character.

Based on the demonstration (scaffolding) and instruction given by the virtual character, the children imitate its movement and develop the respective skill. In addition, the instant feedback given to the children improves their performance in psychomotor skills. Moreover, the proposed system also fosters the mastery of psychomotor skills through the reinforcement of particular skillset. The result shows that the children in the experimental group have developed several psychomotor motor skills and passed developmental milestones for a child at age 4, including jumping, hopping, balancing and catching a ball. Moreover, the outcomes of the study are in-line with the children motor competence studies that demonstrates that balancing skills are highly correlated with gross motor skill such as jumping and kicking.

In conclusion, our study shows that the development of language and communication, cognitive, and psychomotor skills is interrelated at different degrees of correlation. This is clear when we look at the results of the analysis of performance for those children in the experimental group in the aforementioned areas of development. The proposed framework has improved the development of language and communication, cognitive, and psychomotor skills of the preschool children. This was the goal of this research.

6.3 Limitations of the Study

This study has several limitations. They are reported below:-

i. Due to the time and resource constraints in accomplishing the objectives defined in section 1.4, this study focuses only the language and communication, cognitive and psychomotor development of preschool children. The socio-emotional development, spiritual and moral development, and aesthetic and creative development were excluded.

ii. The research produced only short-term effects on the performance of preschool children. A longitudinal design would be useful in evaluating the effectiveness of the proposed framework in promoting the performance and development of the aforementioned areas for preschool children.

iii. The study subject focused on aged 4 children. Further studies of children of different age groups, races, religions, subjects, and languages, should be carried out in order to investigate the usefulness of the proposed framework in assisting the teacher in teaching and improving the learning of preschool children.

6.4 Future Directions

This study has provided much evidence on the effectiveness of the proposed framework in assisting teachers in teaching and improving preschool children's learning. Future research can enlarge the scope of the study to other subjects (i.e. science, music, visual motor skill, and coordination skill) and languages (e.g., Chinese and Malay). In addition, the effect of the proposed framework applied to children from different age groups, races, religions, and native languages, could be investigated further. Last but not least, a longitudinal design is recommended for future research to provide more evidence of the impact of the proposed framework in preschool learning.

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LIST OF PUBLICATIONS AND PAPERS PRESENTED

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Lai, N.K., Ang, T.F., Por, L.Y., & Liew, C.S (2017). A literature review on the use of digital games in child development studies. *Games and Culture*. (under review)