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Master's Thesis
Academic Year 2015

Tata-N-Taro Adventure: Encouraging Collaboration Between Preschool Children Through Motion Capture Game in Remote Environment

Graduate School of Media Design,
Keio University

Stefanie Angelia

A Master's Thesis
submitted to Graduate School of Media Design, Keio University
in partial fulfillment of the requirements for the degree of
MASTER of Media Design

Stefanie Angelia

Thesis Committee:

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Abstract of Master's Thesis of Academic Year 2015

Tata-N-Taro Adventure: Encouraging Collaboration Between Preschool Children Through Motion Capture Game in Remote Environment

Category: Design

Summary

Children do not develop in an isolated environment.Through relationship and interactions, children collaborate towards a shared goal. By interacting, they learn how to negotiate and follow each other. Research and studies has demonstrated that working in pairs or small groups has advantageous effects on learning and development, especially in young children. Therefore, the understanding about the importance of peer collaboration needs to be taught to young children. This paper proposes a game called Tata N Taro Adventure that employs a motion capture device to encourage collaborations between kindergarten children in remote environment. The game is designed for children from 4-6 years old to explore story lines and play several mini games together in remote environments. By employing Microsoft Kinect, the children could explore things with their body. From 3 experiments, the effectiveness of the game for encouraging collaborations was examined by observing childrens engagement level and interactions. The results show that with the proposed game (through kinesthetic play and different game play) children gained motivation to learn and to interact more with their peers. The study and observation showed that the game also encouraged children to collaborate and to compete healthily with each other.

Keywords:

Kinect, Education, Computer Supported Collaborative Learning

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Chapter 1
Introduction

1.1 Background and Motivation

There is a proverb saying "No Man is an Island". Noone can live by themselves and people will always socialize with other people as long as they live. Human do not grow up in such an isolated environment. They begin to socialize with others since they were young. Socialization is a learning process that begins shortly after birth. Early childhood is the period of the most intense and the most crucial socialization. Children live in a social world consisted of social matrices. They enter into social matrices through interaction with group of children whom they spend together with on a daily basis, called peers.

Based on observation of a kindergarten child, Z (3 years old), a kindergarten student typically spend most of the time in school and home. In home, they interact with their parents and their siblings (if they have any). However, in school - in this case a kindergarten - they mostly interact with teacher and their peers around the same age. This young children interact with each other through playing and these children also have different behaviour when they play. Some children will play along, being very shy and do not seek interaction or show a need to be with others. Some will be content to play by themselves. Most of the time, these children will place their toys near other children, but they do not want share them with others. Other children may request toys from classmates, but not share the ones they claim. In another part of the playground, you may find children who have formed a group game made up of anyone who wants to play. Boys may only play with boys and girls may only play with other girls. Therefore, one of the main purpose of kindergartens or any child care programs is to help children grow from egocentric individuals into youngsters who can work and play cooperatively.

According to Merriam-Webster dictionary, collaboration means work together with another person or group to achieve something together. Human collaborate

even since they were young. Peer collaboration involves children working together to complete a single, unified task that represents the shared meaning and conclusions of the group as a unit. [14]. Collaboration between children is fundamentally social and cognitive in nature [27]. Its social because collaboration involves motivational and affecting factors such as communication and behavior. Its cognitive because it requires planning, strategy, and monitoring.

A lot of studies and researches have proven that collaborative learning and playing benefits a child in many ways. L.S. Vygotsky, a Russian teacher and psychologist stated that socialization affects the learning process in an individual. Collaboration helps to obtain an outcome that no single person could achieve [47]. When children collaborate, they scaffold and model each other. They form a relationship that has a common goal [2]. They communicate their ideas and knowledge verbally and non-verbally at a level that is understood by all the children [19]. However with the advancement of technology, collaboration is not only limited to children who are located in a same physical space, but also it happens between children who live in the other part of the world.

Despite all the benefits of collaborating with each other, children only have the opportunities to collaborate with the peers who have similarities with them. For example, children who go to Kindergarten A will collaborate mostly with children from Kindergarten A. In an environment like kindergarten children are fundamentally relegated into fixed groups and will not have opportunities to mingle outside those groups. Therefore there is a need to give those children such opportunities. Within recent decades, there has been a great deal of research into ways of addressing this problem including the use of technology such as video games.

For the past few years, video games have become one of the profitable forms of entertainment. Technology has enabled game creators to create a video game with rich graphic and crystal clear sound that makes the players immerse in the digital world. Video games are not only limited to the action games, but also strategy, role-playing, simulation, puzzle, sport, and many other genres, including education. Edutainment is a term that is commonly used by the game producers to market titles that have educational potential. As the number of this game in increased, educators have begun to use this kind of game (particularly simulation game) in the classroom [44].

For preschoolers, most of the game provided for them is still in online context. There have been more preschool games entering the console and handheld, but there was not a real preschool market for a video games system [7]. The detailed

reasoning for this issue will be explained in chapter 2.

Nonetheless, the educationist recognized that games could support valuable skill development such as these 7 points [25]:

- Strategic thinking
- Planning
- Communication
- Application of number
- Negotiating skills
- Group decision-making
- Data handling

Video games are not only contributing to individual development, but also social development. When players play in multi-player games, they often collaborate in teams and share knowledge, skills, and value with the others [17].

Now, the advancement of technology has enabled young children to have more access to play games using the console or digital device. A lot of educational practitioners have involved video games in their teaching method. From this point of view, clearly video games have a good prospect as a powerful learning tool. Now the questions has shifted from do video games affects learning to how video games affect learning.

1.2 Defining Educational Game for Children

Educational game -or some people refer as edutainment- is a form of computer games or other entertaining media that enables participant to learn something new [44]. It has been around for sometime, and most of educational institutes have begun to use it as an alternative for traditional teaching method. Malone and Lepper describe a good educational game as in the figure 1.1 [29]:

Wang et al [50] categorize educational games according to these 3 following criteria:

- Player interaction does the game provide player to player interaction
- Fantasy and skill interaction does the game provide fantasy which is integrated with learning goals
- Game concept type - the main concept used in the game.

Key Characteristics of a Learning Game

Malone and Lepper (1987)

a) Challenge is created by having clear, fixed goals that are relevant for the learner. Uncertain outcomes provide challenge by offering variable difficulty levels, hidden information, and randomness. Feedback on performance should be frequent, unambiguous, and supportive. Lastly, the activity should promote feelings of competence for the person involved.

b) Curiosity exists in two different forms: sensory curiosity and cognitive curiosity. Audio and visual effects, particularly, in computer games may enhance sensory curiosity. When learners are surprised or intrigued by paradoxes, or incompleteness, it arouses cognitive curiosity.

c) Control is experienced as feelings of self-determination and control on the part of the learner. The ingredients of contingency, choice, and power contribute to the control feature of the learning experience. When the individuals face choices that produce powerful effect, it increases their sense of personal control.

d) Fantasy encompasses both the emotions and thinking process of the learner. Fantasies should appeal not only to the emotional needs of learners, but should provide relevant metaphors or analogies. Lastly, fantasies should have an integral relationship to the material covered. (Dodge 2000)

Figure 1.1: Key Characteristic of Good Educational Game

Based on those criteria, educational games are categorized into following taxonomy [29]. Figure 1.2

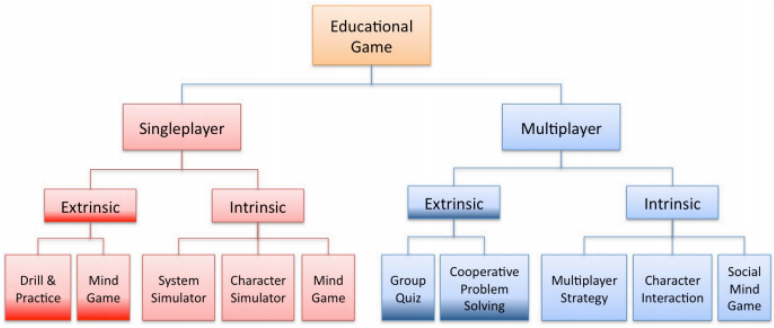

Figure 1.2: The Lecture Games Taxonomy for Educational Games

Computer Supported Cooperative Play (CSCP) is a term used to define a mutual engagement by two or more individuals mediated by a computing environment [50]. It is intimately concerned with education, but it may also involve game. Collaborative does not necessarily mean competition between two groups. It can be a cooperation to reach a common goal. Collaborative game has received more attention for the past years. However, there are not many existing collaborative educational games available.

Nowadays, there are a lot of gaming consoles in the market, such as the Nintendo DS, Microsoft Kinect, and other touch screen interface. Those interfaces enable players to interact in a different way. Combining the new game technology

with the research in educational game, a new type of innovative collaboration game has been born.

1.3 Thesis Objective

This thesis aims to encourage collaboration between preschool children in remote environment using motion capture device. The game itself will be called Tata N Taro Adventure (TNT Adventure).

This research will explain about the detail of the project and the interaction and gameplay provided by the game. The primary goal of this research is the game design that could encourage collaboration between children even though they are not located in a same physical space. The proven would be how motion capture device such as Microsoft Kinect and TNT game concept is actually could really be a communication medium between children and allow children to explore the positive benefits of collaborating.

In this project, author roles as the grand designer and also get involved in the technical part.

1.4 Thesis Overview

There are 6 chapters in this thesis.

The first chapter will explain the background, motivation, and also the objective of the research. The literature review and past related project will be covered in chapter 2. This chapter is related with the research background, which explains the studies of video games in classroom, the playing-learning children, as well as the kinesthetics learning. Chapter 3 explains about the concept and design of the game. Chapter 4 will talk about the implementation of the system. Chapter 5 will address the implementation of the concept, the result of the user testing, and the evaluation. Finally, the final chapter concludes the research and also explains what is needed in the future to develop a collaborative educational game.

Chapter 2
Literature Review

2.1 Playing from Children Perspective

Playing and learning are part of childrens everyday life. When children are asked what they like to do the best, the answers are unanimous: to play. On the other hand, the term school is often associated with an organization for learning. While the school is traditionally seen as a place to learn, preschool is more often associated as a place to play [37].

Many research and studies claim that children may gain knowledge through playing [11, 28]. Play, according to Levin, gives children opportunities to be in control of what is happening and what they know. Play, together with friends, allows children to exercise self-control and develop what they already know, take turns, cooperate and socialize with others [18].

In 1998, The Ministry of Education and Science in Education stated that the environment in preschool must be joyful, must give children a feeling of belonging and must see communication, play and learning as an intertwined totality [37]. In this environment, one can see how children learn through discussing, arguing and exploring each others ideas and ways of thinking [41]. Childrens cooperation and co-learning is extended in preschool [51] and also as transference of culture [24].

In play, children communicate, do role-play, and negotiation with peers. At the same time as they act the play, they produce the content of it by talking about what to do and how should it be done [33,34]. In the 1930s Mildred Parten (1932) described these 6 levels of play [35], used by researchers and those working with children, based on the level of social skills a child is capable of using with peers:

- Unoccupied behavior: looking around at whatever occurs, but not engaging in activities
- Onlooker behavior: watching others play

- Solitary independent play: engaging actively on toys which are different from those used by the other children
- Parallel play: play next to each other, but not in interaction with each other; often use the same toys
- Associative play: play with others, sharing toys, but have no organization of the group to achieve the same goal
- Cooperative play: play as a group that have the same goal

According to Parten [35], as a child grow older, they develop a better communication skills and as interaction between peers become common, the solitary and parallel play become less common and the associative and cooperative play become more common. Marrie Cecchini, a writer and education practitioner added that there are four activities that could help fostering cooperative play [8]:

- Physical play: this type of play required a lot of motor activities. To encourage physical cooperative play, outdoor activities such as camping or playing in the playground is strongly suggested.
- Manipulative play: this type of play emphasizes the manipulation of objects, such as the shape, puzzle piece, building blocks, and etc.
- Symbolic play: this type of play involves pretending as opposed to the reality. Drama and role-playing are the examples of this type of playing.
- Games: games involve activities, which are governed by rules. It could be involving a physical activities or it could be quiet and relaxing like board and cards game.

2.2 The Role of Collaboration

Children live in a social world consisted of social matrices. They enter into social matrices through interaction with group of children whom they spend together with on a daily basis, called peers [10]. By interacting, they learn how to negotiate and follow each other [30]. Children may also have a variety of interaction with their peers that have different processes and developmental effect. Vygotsky stated that children do not develop in an isolated environment, but in a social

matrix [47]. Through relationships and interactions, children collaborate towards a shared goal. And as they work together, cultural understanding is transmitted during the communication. Actions and languages are often used as the media of communication during collaboration.

Peer collaborations involve children working together to complete a single, unified task that represent the shared meaning and conclusions of the groups as a unit [14]. As the technology advance, collaboration is not limited on group activities in classroom anymore, but also up to computer-supported collaborative learning (CSCL). CSCL system involves technology to monitor interaction, regulate task, rules, and roles, and also acts as a mediator [36].

When children from different background and knowledge level collaborate, they learn to communicate on a level that is understandable by all of the children. When children are able to understand the process and the goals of collaboration, inter-subjectivity is formed. Inter-subjectivity is ideally constructed when the children adopt each others perspectives and transfer their ideas successfully through verbal and non-verbal communication [2].

Research and studies has demonstrated that working in pairs or small groups has advantageous effects on learning and development, especially in young children. Research shows that children working collaboratively obtain a combined higher performance output than children working individually [32, 40, 46]. In addition, most of collaboration between children happened when they play. Therefore, encouraging children (with disabilities or non-disabled) to play together is extremely important.

2.3 Learning Through Video Game

Playing has been changed since we arrived in digital era. The advancement of technology has made it possible for children even the ones at very young age- to interact with virtual playground in the tablet or phones under minimum supervision. This kind of skills that have not been observed in the previous generation of children is now starting to emerge.

As the childrens media of playing has evolved, over the past 10 years video games have matured as an entertainment form. The technology have enabled designer to create a digital worlds with rich graphic and sound. The video games producers also offer a lot of genres, from action, puzzle, racing, and education. As game companies market titles with educational potential as edutainment, educa-

tors believe that most children learn best through playing [20, 44].

Video games have been used as a tool to help children or adolescent that have developmental problem such as autism [13]. According to Demarest, some of the therapeutic benefits gained from the video games were the language skills, mathematics and reading skills, and social skills. There are also several studies describing the usage of video games in rehabilitation.

Prensky confirms two reasons why use computer games for learning: todays learner have changed radically, and these learners need to be motivated in new ways [38] . Furthemore Gee, added that games make player think about decision they are making and how the decision will impact on the situation [17].

2.3.1 Key Issues in Developing Games for Learning

However, there are some things that have to be considered when designing a video game for preschoolers. Game maker and producer should understand the characteristic of young learners. Children aging from 3 to 5 are known to have a short attention span. Children ages 5-6 years old typically can attend to one activity that is interesting for them for around 10 to 15 minutes.

For the six-year-old, immobilizing his body and regarding an object fixedly with his eyes for a period of time is a difficult task, tedious, and tiring. Children at this age seem built for action rather than sitting still. The teachers are well aware of the short attention span beginners show. A child of this age can be expected to work at a task at his table for as long as fifteen minutes, but usually when he can alternate sitting and standing during the time [21].

There are two things that have to be put into consideration when designing a game for children with short attention span:

- Gain the children interest. Visual, colors, and arts could help children sit and focus for an extended time.
- Storytelling. Interactive story system might help children focus. For preschool aged children, a very short story is normally used, and gradually makes the stories longer.

The other thing that has to be considered when designing video game for preschoolers is their motor skill. Motor skills often categorized into gross motor skill (or movement skill), which require the usage of larger muscles, and fine motor skill (manipulative skill), which involves smaller muscles such as finger

dexterity and wrist flexibility [7]. During the preschool years, children become increasingly efficient in gross motor locomotion, posture and balance control, and object manipulation [50].

Based on the characteristic of young learners, designing video game for them is a daunting task for video game producers. Revelle and Medoff review some of the basic reasons why home entertainment systems, computers, and other electronic gaming devices are often difficult for preschoolers to use. In addition to their still developing motor skills (which make manipulating a controller with small buttons difficult), preschool children might not be able to understand that there is a direct link between how the controller is used and the activities that appear before them on screen [39].

The vast of majority of preschoolers are still unable to read and write. Thus, using text-based menu is not viable. Preschooler lack of fine motor control, cognitive understanding of the mapping between controller use and on screen activities raises important considerations when it comes to game design and play. According to Kirriemuir, there are 2 key themes common to the development of games for education, namely [25]

- Making learning fun
- Learning through doing

In addition, Fisch [15] suggest that in order to make educational video games educational, game makers and producers should 1) matching the educational topic to the media, 2) placing educational content at the heart of the gameplay and 3) building feedback that supports learners into handling of difficult content.

2.4 Learning Style

Learning styles can be defined in a lot of ways depending on ones perspective. Brown (2000) defines learning style as manner in which individual perceive and process information in learning situations [6]. David Kolb [26] on the other hand, defines his learning style as Experiential Learning Theory (ELT) which involves 2 major dimensions of learning: perception and processing. The dimensions are visualized as two intersecting axes as shown as the figure 2.1 below.

Celce-Murcia (2001) defines learning styles as general approaches, such as global-analytics or auditory-visual. Generally, there are 3 types of learning, which are described in the following points [9]:

- Visual Visual learners learn by watching and learn best using visual image.

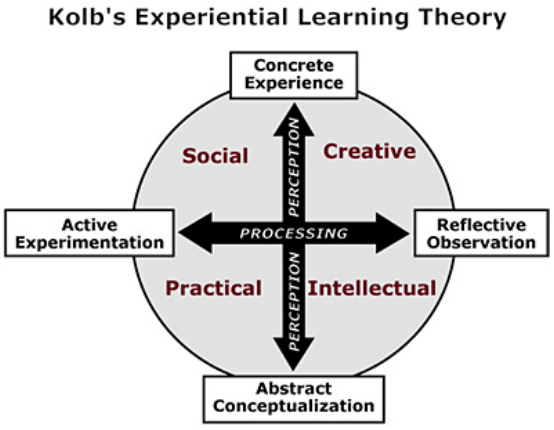

Figure 2.1: Kolb's Learning Theory

This type of learner can be taught using symbols or pictures, highlighter pens, flash cards, and non-verbal cues such as body language.

- Auditory Auditory learners learn through listening and interpret the information by means of pitch, speed, and emphasis. This type of learner may obtain information by reading out loud or having another person read for them.

- Kinesthetic Kinesthetic or physical learners learn through movement and interaction with physical world. Most of children in kindergarten are identified as physical learner and most of them will change into visual or auditory learners by 2nd or 3rd year.

In addition, Howard Gardner introduced the theory of multiple intelligences (MI) that classifies human intelligent into 8 types. One of them is bodily-kinesthetic intelligence, which describe ones abilities to control body movements has a relation with educational potential provided by gesture-based computing [16].

2.4.1 The Usage of Kinect in Classroom

Kinect can be considered as an inexpensive tool that can support learning in classroom. However the applications for kinect in education is not that many. Basically, Kinects potential can be described into 2 categories: a tool to enhance

teaching and tool to support learning. As a tool for teaching, Kinect has these 4 characteristic as described below [23]:

- Flexible teaching tool. Teacher can easily create multi-sensory interactive activity because Kinect integrate body and gesture movement into classroom activities [5]
- Kinect can accommodate multiple users.
- It is a versatile tool because it collects three-dimensional information
- It engages student.

As a tool to support learning, kinect has these 3 characteristic as described below [23]:

- It is a stimulating tool. A classroom equipped with kinect should be able to create a enjoyable environment that could help boosting learning motivation.
- Kinect facilitates kinesthetic interactions and is able to coordinate with visual and auditory information to reinforce learning
- It could be combined with another softwares to enhance the learning experience. Kinect can extent the varieties of interactions type supported by the softwares and bring the new features created by the children. Mikumiku dance is one of the example.

Another research about using embodied interactions to improve learning performance has been done by Wanju-Lee et al [48]. In the research, Lee employed a Microsoft Kinect to create a digital learning playground (DLP); illustrated in figure 2.2 below.

The results shows that there was much fun adding Kinect to the DLP because the players were not only have a good time seeing their peers on the screen, but also players could adjust their performance by observing the peers. In addition, the usage of Kinect in classroom is often associated as a tool to help children with motor impairment, ADHD, and autism. Children with autism are often competitive and unable to express their wishes, resulting they hardly cooperate with another children. The fact that Kinect accommodate multiple users, allow those children to be able to work in team and gradually develop their oral expression [5]. Kinems (www.kinems.com) is one of game makers that develop innovative, configurable Kinect-learning games based on therapeutic protocol.

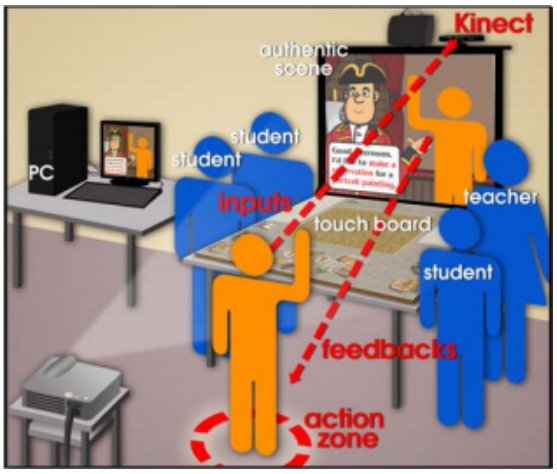

Figure 2.2: Mechanism between user and DLP through Kinect

2.5 Related Project

2.5.1 Kidpad

Collaborative storytelling helps children develop interpersonal and story-related skills. It can also help children to develop communication skills. These skills are needed for collaboration, and learning to work with the peers is another important skill to require [12]. Collaborative storytelling usually happens when children play. However, here are not many system designed to support collaborative storytelling.

Kidpad is a collaborative storytelling tools for children. It enables children to draw, type, and hyperlink in a large two-dimensional space. With these capabilities, children can create story by drawing scenes and linking them together in two-dimensional space [22]. Kidpad also supports multiple users with the help of multiple mice on a single computer.

Instead of using menus or tool palletes, Kidpad use a local tool as its menu [3]. Local tools provide a concrete visual interface, so its easier for young children to use. Each user can control one local tool at one time. They can change their local tool by picking up an unused local tool or exchange their tool with other user. Some local tool can change their behavior when they are used together, for example when two local tools are close to each other, they can create a new color [4].

Kidpad (Figure 2.3) is equipped with toolbox that contains some tools, which are useful for creating the story. A crayon is used to draw a scene, a magic wand

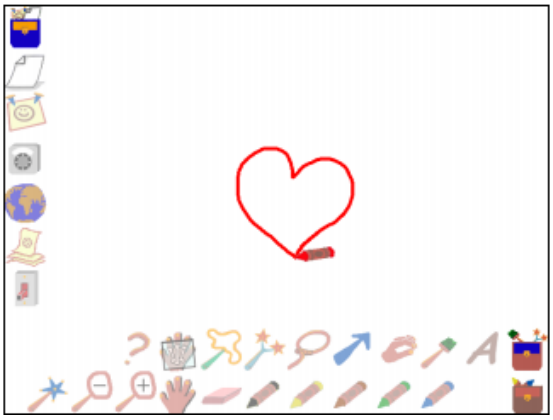

Figure 2.3: The Interface of Kidpad

is used to link between scenes, a magnificent glass is needed to zoom the space, and many other tools.

In todays technology, most computers are designed to support one individual at one device. In school, its common to see that pair of students or group of students work together in a computer. However, in a group work using single computer, there is a tendency that one student has the control of the computer at a time.

An observation study was carried out where pairs of children were asked to complete a story task using Kidpad using one or two mice. Twelve pairs of children aged between 6 and 7 are divided into 2 groups. The first group works with one mouse and the other works with two mice. Figure 2.4 illustrate the story created with Kidpad.

Figure 2.4: Story created using the Kidpad

In the one mouse condition 42% time was spent actively drawing, whereas in

the two mice condition the time spent was 73.3%. In one mouse condition, the children were inactive (not involved in any task, either drawing nor observing their partners) for 48.28%, whereas in the two mice condition the children were inactive for 17% of them time. Non-attentive behavior (such as looking away from the screen) was quite low for both one mouse and two mice condition, which are 3.42% and 0.9% respectively [45].

Figure 2.5 and figure 2.6 describe the distribution of the mouse usage between the left hand and right hand side.

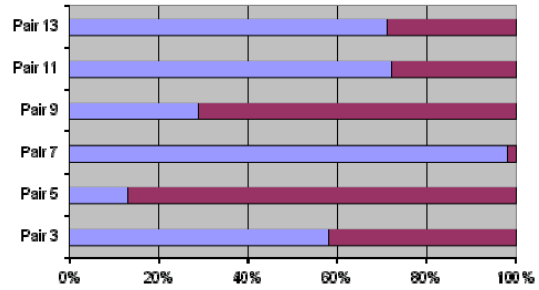

Figure 2.5: The Distribution of Mouse Usage in Left Side and Right Side Within The One Mouse Condition Group

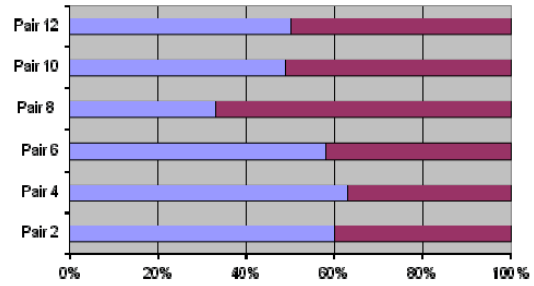

Figure 2.6: The Distribution of Mouse Usage in Left Side and Right Side Within The Two Mice Condition Group

The access to the mouse does not actually portray how much the children collaborate. The children in one mouse condition, for example, collaborate by discussing ideas before the ideas were implemented in the computer. There was also a case where one child dominated the work.

Based on that study, it is believed that multiple mice may facilitate children to collaborate and work together. However, there were some limitations to this

type of technology. First is the physical size of the output device cannot support more than a few students working simultaneously. The other problem is usability problem. Most of the actions facilitated by the Kidpad only enabled two or more users to work simultaneously. Some of the actions that only allowed one user to carry them out, for example navigating, often disrupted the partner from doing their task.

2.5.2 Revised Kidpad and Klump

In contrast with the approach offered by the Kidpad, Klump use a modeling approach as their storytelling tool. Klump is a collaborative 3D story telling tools. Klump provides a textured deformable 3D polygon mesh that can be stretched, textured, and colored. It also makes sound when it is manipulated [4].

Figure 2.7: The Klump

The Klump (Figure 2.7) can also enable collaboration by allowing synchronous multi-user access and displaying the cursors next to each other. Interface that encourage collaboration were proposed in the research. The interface should give opportunity to explore the benefit of collaboration in such a natural and subtle way.

In the research, the Kidpad were redesigned to encourage collaboration by supporting tool mixing. When two children use mixable tools at the same place and time, the tools will have an enhanced function. The concrete example is when

children draw with 2 crayons close to each other; the result is a filled area whose color is the mix between 2 colors. In this case, children can still work individually, but they gain benefit when they choose to work together. The approach adopted when revising the Kidpad is children should be able to finish a task individually using the Kidpad, but when children collaborate, the result will be enhanced [4]. Figure 2.8 illustrate the redesigned version of Kidpad.

Figure 2.8: The revised version of Kidpad

In order to support collaboration, the Klump was also redesigned. The redesigned version was focused on the action of stretching and texturing. In the redesigned version, children may stretch the Klump together. The redesigned version of the Klump also allows children to have a new texture if 2 textures are applied together, for example, the texture happy combined with the texture sad will resulted in a mix emotion. Figure 2.9 describes the revised version of the Klump.

A group of children were tested to use the revised version of Kidpad and Klump. They were asked to create at least 3 scenes. They collaborated throughout the process, making extensive use of the collaborative tools before starting the story, trying out the different possibilities. However, they did not use the collaborative tool behaviors in the actual story creation [4].

The children that used KidPad for the first time had a hard time collaborating. They tried to use the tools and the collaborative tools. However, most of what they did however was scribbling [3]. This group found it hard to identify each

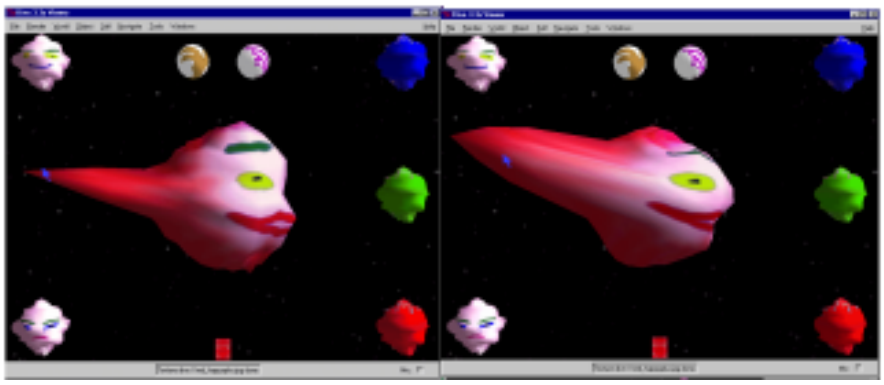

Figure 2.9: The revised version of The Klump

others cursors and to negotiate collaboration. These observations suggest that young children are able to use some of the collaborative features of KidPad and the Klump and that they can enjoy doing so.

2.5.3 Word Out

Word out is an interactive game to learn alphabet through full body interaction. It is targeted for 4-7 years old children. Word out uses Microsoft Kinect to detect the silhouette of players [52]. The players should twist their body to match the shape of the letter shown in the screen. They are allowed to use items or they can work together to create the letter. Figure 2.10 illustrates word out demostration.

Figure 2.10: Word Out

Word out was exhibited in two museums, the Art Science Museum of Singapore and the National Museum of Singapore. 84% of the total plays were collaborative

plays. The children played with siblings, parents, teachers, or even strangers. The collaboration happened naturally. Some children directed others, such as You stand here and Ill stand here and make the middle line. when making H. Others asked for help when they realized they could not do it alone [52]. Children who wait their turn to play also shouted ideas to form the letter, such as Lift your leg, even though they did not know the child playing.

2.5.4 Collaborative Game Using Shared Virtual Display

In this research, 3 collaborative settings were investigated: (a) shared display, (b) side by side display, (c) separated display. Figure 2.11 shows the 3 different settings [43].

Figure 2.11: Three Different Collaborative Setting

Figure 2.12 shows the collaborative mathematics game. Pairs of children were asked to play a collaborative mathematics game. Each child controlled a climber and they had to work together to climb to the top of a mountain. A rope connected the climbers. The mountain consisted of stacked hexagon blocks containing numbers. Climbers could not occupy numbers that share a common factor (other than one) and the distance between climbers could span at most three hexagons. Thus, when players moved to hexagons containing common factors, one climber would fall off. The goal was to climb as many mountains as possible. [43]

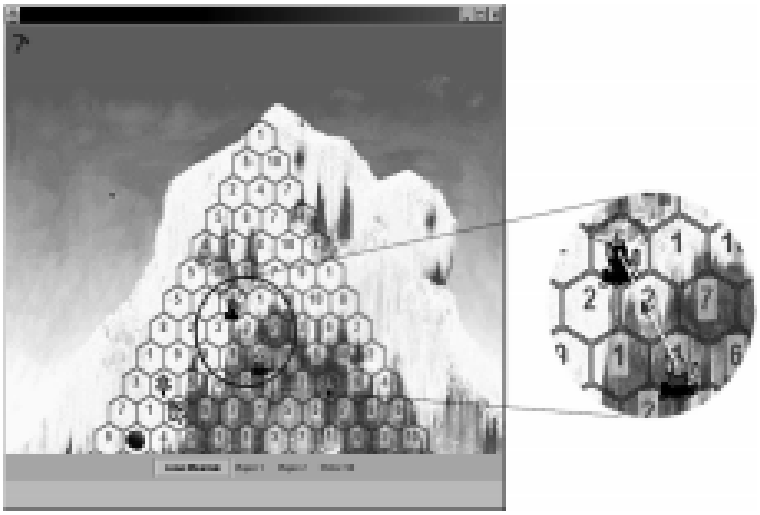

Figure 2.12: The Collaborative Math Game

Chapter 3
Tata-N-Taro Adventure

3.1 Fieldwork

The fieldwork is conducted before creating the concept of TNT Adventure. The fieldwork will be explained into 2 subsections - the goal and the result-.

3.1.1 Fieldwork Goal and Implementation

Before designing Tata N Taro Adventure game, a fieldwork is conducted to know if the children are familiar and able to use the motion capture device. The fieldwork also aims to determine what type of game will be suitable and playable for children ages from 3 to 5 years old and also to know the ability of the children.

The fieldwork was done in August 2014 in a kindergarten (child care center) B in Hiyoshi, Kanagawa. The fieldwork was done from 12 to 3 PM. Six children aging 4 and 5 years old participated in this fieldwork. Those 6 children consisted of 3 boys and 3 girls and their nationality are Japanese.

In the fieldwork, a leap motion was used as the motion capture device and several games were used to test the ability of the children and to know whether the game is enjoyable and fun enough for the children. Figure 3.1 shows the 3 games which were used in the fieldwork;they were:

- Caterpillar count: a single-player mathematics game where the children have to line up numbers.
- Marionette Zoo: a digital puppet game, where the children can use their fingers to move the characters and tell stories based on the background they choose. One or two people can play it.
- Sky alphabet: a single-player game to help the children writing the alphabet.

Figure 3.1: List of Game used in the fieldwork

All of the games are available in the leap motion application store. However, all the instructions are written in English. The children were allowed to choose the game they want to play, and they will play one by one. An instructor who explained the rules and game play accompanied the children. The entire process of fieldwork was documented in photos and videos.

3.1.2 Fieldwork Result and Evaluation

Based on the fieldwork observation, it is known that it was the first time for the children to see and use leap motion. However, when they were asked if they like to play game, all the children said they really like to play game and usually they play computer games or mobile phone game.

The children needed couples of minutes to be able to use the leap motion. Figure 3.2 describes the time which was needed by the children to use the leap motion.

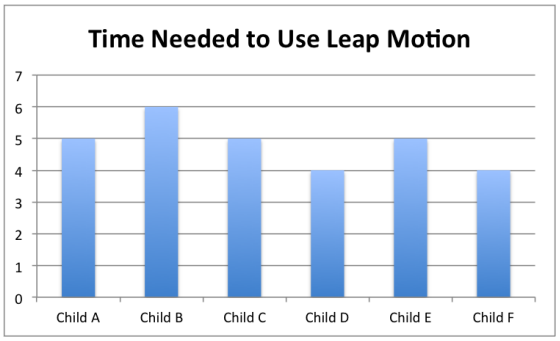

Figure 3.2: The time needed to use the leap motion

However, because the scope of the leap motion is not too wide and the position and range between the childrens hands and leap motion also contribute to the accuracy of the leap motion, sometimes in the middle of the game, the leap motion suddenly lost track of the gesture and the position of the hands had to be re-calibrate.

When the children were using the Marionette Zoo, these following 4 aspects were noted:

- They were focus on the game and did not distracted with other things. Figure 3.3 shows how the child played with the leap motion.
- When two fingers were too close to each other, the movement of the character became unpredictable. This case happened a lot because the childrens fingers were quite small.
- It was difficult for the children to play using two hands because the characters were too hard to be controlled.
- They tended to just play without telling story.

Figure 3.3: A child played the leap motion

When the children played the Caterpillar Count and the Sky Alphabet, these following 3 aspects were noted:

- They were focus on the game and did not distracted with other things.
- There were some cases of false positive input where the pointer suddenly move to a position even though the children did not pointed to that area.
- In Sky Alphabet, there were some cases of false negative input where the children already stroked according to the letters shape, but the letter did not formed in the game.

Other general aspect that was noted is most of the children were just stating to learn how to write and read. Therefore, its hard for them to read the instruction in English.

Based on the result of the fieldwork, it could be conclude that a game that does not require multi-tasking (like telling story and moving body part) might be more suitable for children that ages. In addition, another motion capture device that is more accurate and have a wider range might be more suitable for children.

3.2 TNT Concept

The name TNT adventure comes from the main characters name Tata and Taro. TNT Adventure was originally targeting an Indonesian and Japanese kindergarten children; therefore the author tries to put both countries vibe in the characters name and design. Figure 3.4 shows the characters of TNT Adventure. As the project developed, TNT was not only targeted to Indonesian and Japanese kindergarten children, but also kindergarten children in general.

Figure 3.4: Tata and Taro

This research aims to create interactive kinesthetic video games for kindergarten children that could encourage children to collaborate with each other even when they are not located in the same physical space. With this concept, the collaboration between children will not only limited by the space, but they can also collaborate using another method the gesture.

TNT is a choose-your-own-adventure game, which revolves around the daily life of Tata and Taro. Choose-your-own-adventure is originally a genre of game book where each story is written from a second-person point of view. The reader

is assumed as the protagonist and the reader should make choices that determine the characters actions and plots outcome. Figure 3.5 illustrate the connection between the player and the character.

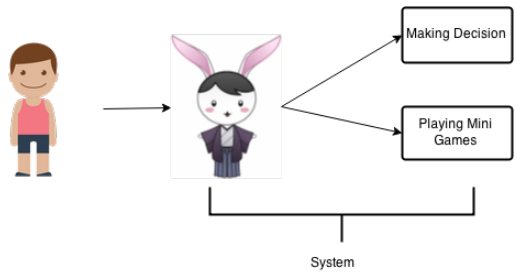

Figure 3.5: Child plays as the Character

Based on the definition of choose-your-own-adventure, the children will play the game as either Tata or Taro. The children will decide the plots outcome by choosing the action that will be done by Tata or Taro in turn-taking behavior. This means, TNT adventure cannot be played by a single user. The story is already predefined and it has some story branches. Depending on the childrens choice, they might get different ending. The storyline is described in the figure 3.6.

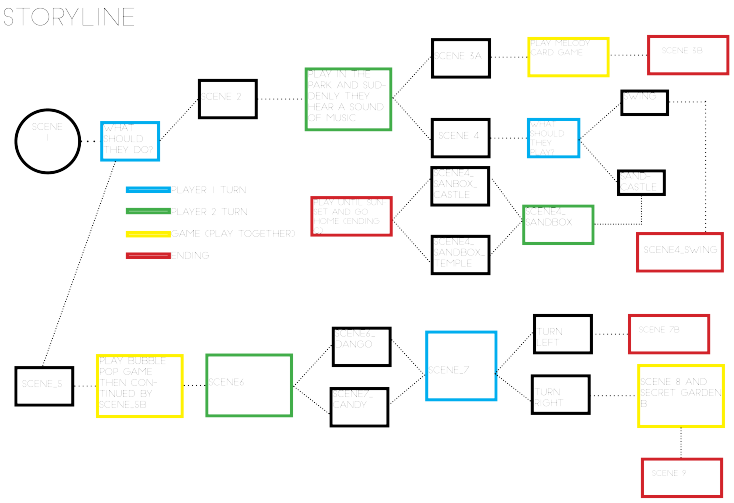

Figure 3.6: The Storyline of TNT Adventure

In order to make the game interesting and let the children explore the game using their body, mini games are inserted in the storyline. The mini games are related to the story, so the children might or might not play the game depends on the choice they make. The children will follow the story as Tata and Taro, resulting that the children could play as if they are the main character of the game.

TNT Adventure is a game that combines the unique feature of each activity that could help fostering cooperative play (as explained in chapter 2). By incorporating the choose-your-own-adventure game, the children may do the role-playing. By employing the motion capture device, TNT adventure may support the idea of physical playing. And by inserting some mini games and puzzles, TNT Adventure is considered as a game. Table 3.1 below explains the relation between TNT Adventure and the activities that could help fostering cooperative play is explained in the .

Table 3.1: Comparison between TNT Adventure and Cooperative Games

Activities that fostering cooperative play	Physical Play	Symbolic Play	Games
Characteristic of each activities	Involving motor activity	Involving pretend as opposed to reality (role-playing)	Involving rules
TNT Adventure	Employing motion capture device to support kinesthetic learning	Choose-your-own-adventure genre to determine characters action and plot output	Mini games with rules and directions to be followed

Ideally in the future this project can be used as a connecting bridge for children in all over the world. Collaborating is an easy task, if the participants are already known each other, but collaborating with someone new is a challenge. In this globalization era, collaboration is done not only with the people locally, but also internationally. To do this, the importance of collaboration should be taught to the children since they were young. It should be taught in the most subtle and natural way as possible.

TNT Adventure does not require a sophisticated device and a lot of space. Technically, a motion capture device, a computer, and a stable Internet connection are needed to be able to play the game. An additional screen can be installed optionally if the number of student in the class is too big. Basically, children should be able to enjoy and have fun during the process of learning in the classroom. Thats why usually kindergarten classroom are spacious and have less desks and chairs compared to primary school. By utilizing this space in the classroom, children should be able to move their body and play TNT Adventure.

TNT adventure targeted kindergarten children ages from 4 to 5 years old. Using the Internet, TNT can connect 2 groups of children who are not located in the same physical place. And by using the motion capture device, hopefully children will be able to collaborate even though they dont share the same language.

3.3 TNT Design

TNT Adventure is created to encourage collaboration between children who are located in remote environment. Remote environment can be interpreted as not located in the same physical space. The example of TNT Adventure environment can be described in the figure 3.7.

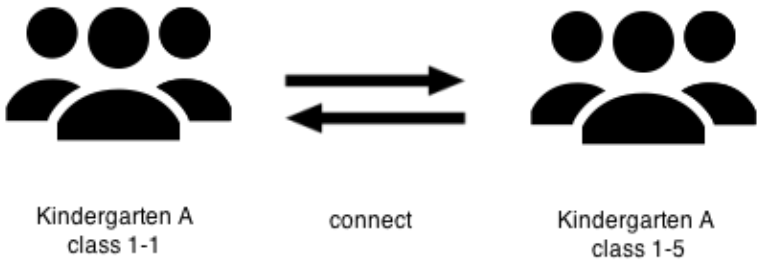

Figure 3.7: Example of TNT Adventure Environment

The main input of this game is the gesture done by the children and captured by the motion capture device. TNT Adventure has to be played by more than one group of children. TNT Adventure can support one player per one Kinect. However, there are 2 types of players in TNT Adventure.

- Active player: The players who have control of the Kinect

- Passive player: The players who act as the spectator

In order to create an educational game that could encourage collaboration between children, TNT Adventure is designed based on 3 keys principles, which is the form of game and relation with the collaboration, the usability of the motion capture device, and the understanding of the game play.

3.3.1 Principle Explained

3.3.2 Between the form of the Game and the Collaboration

Collaboration refers to the form of collaboration expected from the children. The element of collaboration consists of the collaboration between the passive players and the active players, and between the active players with the other active players. Table3.2 explains the type of collaboration between players.

Table 3.2: Type of Collaboration between Players

Collaboration between active player active player	Collaboration between passive players active players
• Negotiating if they dont agree on the same choice • Giving hints through hand motion • Competing with each other	• Cheering the active players • Giving hints to the active players

In order to make the collaboration happen, the game is designed in both turn taking and competition mode. In the story line choosing game, the children have to choose in turn taking behavior. By applying the turn-taking mode, the children are encouraged to discuss their choices with their partner even though they have the option to make the choice by themselves.

In the mini-game secret garden, the children have to look for fruits hidden in the garden. Both players compete with each other to find the fruits. Through the competition, the passive players are encouraged to cheer for the active player within the same group. The active player and the passive players can create a mutual feeling to win.

In the mini-game bubble pop, both active players have to match a silhouette with the item in the bubbles. Both of the active players should guess the same

correct answer in order to proceed to the next level. By synchronizing their action, the player who has a better knowledge i.e the one who could guess the correct answer faster, can share their knowledge by giving hints to the other player.

Usability of the Kinect

The Kinect plays an important part to keep the players (both active and passive) entertained and focus to the game. Children at 4-5 years old are known to have a short attention span. An activity where the children can move around can help improving their attention span. By employing the kinect, the collaboration learning process could be done in a fun and natural way. Playing using a Kinect might be a little bit tricky for children, but it also keeps them entertained. If the game gets too easy for the children, they will get bored in a couple of minutes.

The Kinect also plays an important part as connecting bridge between the two active players. Since in the most case the two active players could not see each other, they can use their gesture to communicate e.g by hovering their hands in a certain object to give hints to another player.

Game Understanding

The understanding of the game is talking about whether the children know what they actually do in the system. It is also talking about if the children know whose turn it is and which hands belong to whom. The children do not have to understand the whole narrative. It is more important for the children to know about what goal that they have to achieve in this game and how could they work together to achieve that goal. However, understanding the whole game (including the story) would be a plus.

3.3.3 Tata n Taro Adventure Game Application

TNT Adventure consists of a Choose-your-own-adventure game as its core and three different mini games to support the main games. In the choose-your-own-adventure game, the player has to make choice for Tata and Taro, and the choice will affect the outcome of the plot. The story has several ending and once a story is finished, the player can play again from the beginning to try the different plot.

Depending on the plot, a player may encounter a mini-game. Table 3.3 below describes the characteristic and game play of each mini game.

Table 3.3: Characteristic of TNT Mini Games

Mini Game Name	Characteristic	Game Play
Hidden Melody	• Karuta style game • Turn-taking	• Player has to listen to several songs from several countries. • After listening, a song will be played and the player have to match the song with the country
Bubble Pop	Matching answer between two player	Player has to match a silhouette with the correct answer
Secret Garden	Competition, 2 players play simultaneously	Player has to find several fruits hidden in the game

The game TNT Adventure has to be played by more than 1 person. When the players run the game, they have to agree which one will host the game and which one will join the game. The player who hosts the game will be the player 1 and the one who joins the game will be player 2.

Each mini games have 10 minutes as the time limit. The time limit is set at 10 minutes because the average attention span between children aging from 3-5 years old is less than 10 minutes. The game architecture will be described in the next chapter. Player one has the right to choose what game they want to play. TNT Adventure consists of choose-your-own-adventure story game and there are 3 mini games related to the story. If players do not want to follow the story, they can skip the story by choosing the mini games they want to play in the main menu. Figure 3.8 and 3.9 illustrate the main menu and sub menu of TNT Adventure.

Figure 3.8: Main Menu of TNT Adventure

Figure 3.9: Sub Menu of TNT Adventure

Before playing the game, an avatar (Figure 3.10) will be displayed on the screen. This avatar is the mirrored version of the player. The function of this avatar is to let the children be familiar with the Kinect, so they can understand what actually the system do and the connection between the game and their body movement.

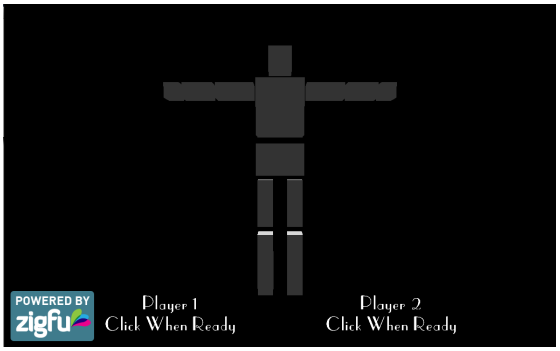

Figure 3.10: The Avatar Moves according to the Player's Movement

If players decide to follow the story, the predefined story will be played. Players can follow the storyline and at some point they will be asked to choose which storyline they want to follow. The players take turn to choose the decision. For example, when player 1 chooses a storyline, in the next turn, player 2 will choose a storyline. Figure 3.11 illustrate the decision making between the players.

Figure 3.11: Example of the Decision Making

Players make their choice by hovering their hands for 5 seconds on top of the choices given on the screen. Depending on the storyline they choose, they might encounter a mini game related to the story. As it is mentioned above, the players can also play the mini game separately from the main menu.

Hidden Melody

Hidden Melody is the first mini game that will be encountered by the players according to the choices they made. Hidden Melody was inspired by Japanese traditional card play called Karuta. The basic idea of karuta is to decide which card out of set of cards is required, and grab that card before the opponent get the card.

Figure 3.12: Hidden Melody's Practice Session

As shown in figure 3.12 above the children will be given extra time to practice. In this game, players have to listen to 7 countries traditional songs. After they finish listening to the songs, a random song will be played and they have to match the song with the flag of the country. To match the song with the flag, the player have to hover their hand above the flag for 5 seconds. Figure 3.13 shows game play of Hidden Melody.

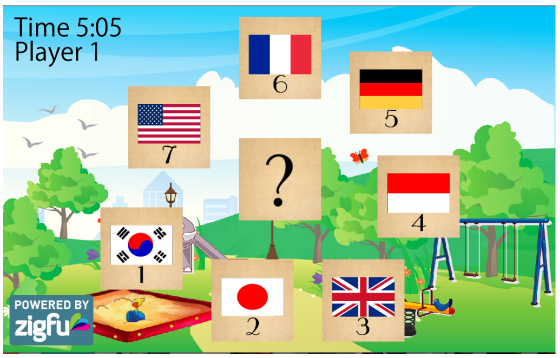

Figure 3.13: Interface of Hidden Melody

By using Karuta style, children can collaborate by competing with each other, or the passive player (the children who are currently watching and not playing) can give hints or direction to the active player (the children who are currently actively involved in the game). Beside encouraging collaboration, by showing countries flag and traditional songs, it is hoped that the children can be familiar with other countries culture and background.

Bubble Pop

The idea of Bubble Pop mini-game is to match a silhouette of an instrument (the question) with the instrument in the bubble (answer). Both players have to put the same correct answers in the box provided. If one of the players put a wrong answer, the new question will not be given and they cannot proceed unless both of them get the correct answer. Figure 3.14 shows the game play of Bubble Pop.

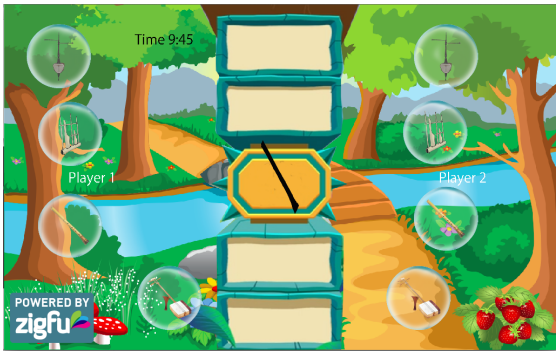

Figure 3.14: Interface of Bubble Pop

In this game, the screen will be divided into 2 parts, the left part for player one and the right part for player 2. To match the silhouette with the instrument, the player have to drag the bubble on their side to the box given. Players have to hover their hands above the bubble for 5 seconds. The bubble then will be attached to the hand, and the have to move their hand slowly to the boxes that separate the screen into two parts.

By using this kind of method, it is hoped that the children who have a better understanding about the silhouette will help the children who cannot get the right answer. In short, they can share knowledge and they will learn about empathy and patience toward another children. Also, by allowing the children to move their limbs will train the coordination between the eyes and the movement.

Secret Garden

Secret Garden is the last mini game that could be found in TNT Adventure. In this game, the children are asked to find a fruit hidden in the game. An icon of fruit will be visible on the top of the screen, and the children have to find the fruits in the screen. Again, the passive players could give direction and hints to the active players. Figure 3.15 shows the game play of Secret Garden.

Figure 3.15: Interface of Secret Garden

The fruits hidden in this game is the fruit that normally children cannot find in non-tropical country, so it will also give new knowledge for the children.

Chapter 4
TNT Implementation

The proposed solution was built as a Desktop / PC game and was called Tata N Taro Adventure. A real working application was developed in January 2015. The application should work in any PC regardless the operating system. In order to run the application, the user will need a computer, a Kinect, and a stable internet connection.

The application is developed in Unity using C# programming language and additional Zigfu plug-in. Figure 4.1 explains the layers of the game.

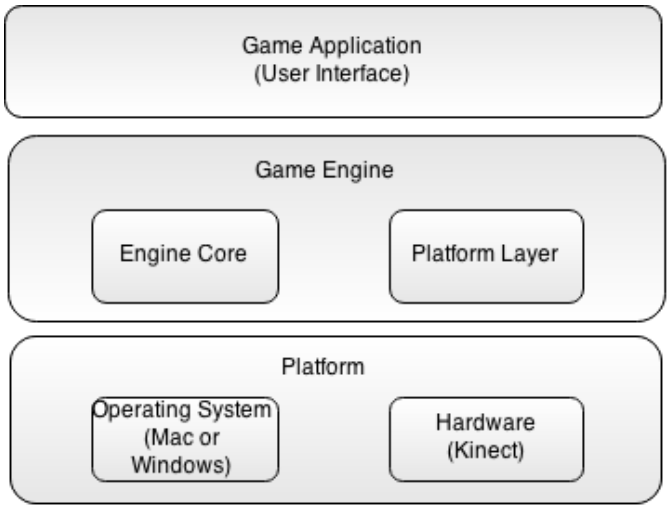

Figure 4.1: Tata and Taro Architecture

The game application layer has been described in the previous chapter as part of the design. This chapter will focus on the implementation of the system.

4.1 Game Engine Layer

The game engine unity is used to develop TNT Adventure. Unity has a built-in visual editor that makes it easier to modify. However, the most impressive feature of unity is probably its ability to build projects for multiple platforms without additional changes to the project. Unity supports several robust programming languages such as javascript and C#. TNT Adventure is developed using C#.

Zigfu is an additional plugin that supports both Unity native and WebPlayer builds for motion-controlled apps. The Zigfu Development Kit (ZDK) comes out with fully functional sample scenes and it works with Mac OS and Windows OS.

In order to connect 2 computers, both of the computers have to be connected through the Internet in peer-to-peer relationship. When 2 computers communicating as equal partner, the relationship is called peer-to-peer. In peer-to-peer communication, each workstation has the same capabilities and responsibilities and either party can initiate communication session. The peer-to-peer communication is illustrated in the figure 4.2 below.

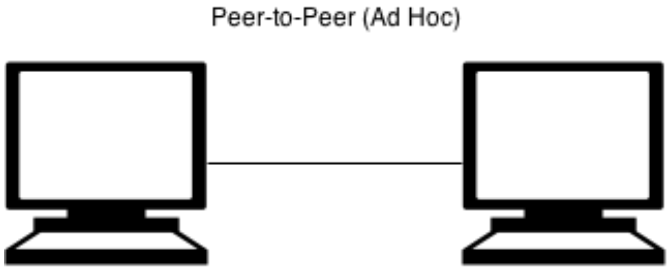

Figure 4.2: Peer-to-Peer Mode

When a player decide to be the one who host the game, the workstation will send its IP Address to master server provided by the unity. The player who will join the game will request the hosts IP address to the master server. When the computer receives the hosts IP address, a connection between two players is formed.

Master server is a meeting place that puts game instances in touch with the player clients who want to connect to them. (reference). There are two function used to exchange that data, which are MasterServer.RegisterHost() for the server and MasterServer.RequestHostList() for the client. For each player who run the game, they provide a game type to the Master Server. When a player connects to the Master Server and request for matching Game Type, the server responds with

the name of the running game, the number of connected players, and the internal IP address of the host.

4.2 Platform Layer

The discussion on platform layer will be focused on the hardware used in the project.

Kinect is a motion capture device designed by Microsoft. It can capture, track, and decipher body movement, gestures, and voice. The auditory and visual inputs act as control to interact with the digital contents in the game. Keyboard, joystick, and mouse do not limit users, thus they can have more interactive experience [23]. Figure 4.3 explains the Kinect's component.

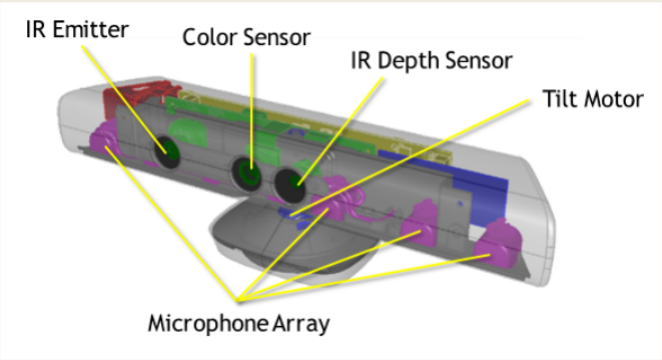

Figure 4.3: The Anatomy of Kinect

It was originally designed for the Xbox 360, but in July 2011, Microsoft lauched a Software Development Kit (SDK) for Windows, which makes the application of Kinect is not limited for Xbox only. However not all operating systems work with the Kinect. There are 2 types of Kinects in the market, the X-Box Kinect and Microsoft Kinect. The usage of Microsoft Kinect in Macintosh operating system will require an additional drive installation.

Tata and Taro Adventure is developed to be used with Kinect because Kinect has the ability to do full body skeletal tracking. In short, the range is not as limited as leap motion. Kinect can recognize up to 6 people and track 2 people. In default range mode, Kinect can see people standing between 0.8 meters to 4.0 meters away; users will have to be able to use their arms at that distance, suggesting a practical range of 1.2 to 3.5 meters. In near range mode, Kinect can

see people standing between 0.4 meters (1.3 feet) and 3.0 meters (9.8 feet); it has a practical range of 0.8 to 2.5 meters [1]. Figure 4.4 shows the range of Kinect.

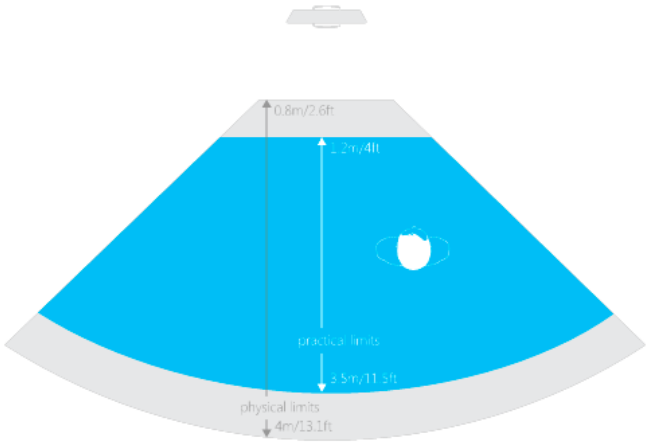

Figure 4.4: Kinect's Range in Normal Mode

As for the affordance of Kinect in the classroom, Kinect is relatively low-cost compared to other solution as it costs around US $149. As long as the classroom is equipped with a computer and a screen, Kinect could be considered as inexpensive teaching tools.

4.3 System Configuration

Figure fig:sysconfig below describe the system configuration.

The users will be located into 2 different locations. It could be different room, different school, or even different city. In each location, a computer will be connected to a Kinect and a projector. Then the connection between the computers happens through the network (P2P Connection). The idea of installing additional screen to the computer is intended to help the passive players to see the screen better. If the passive players can see the whole game better, hopefully they can be more actively engaged in the game. Figure 4.5 illustrate the general system configuration.

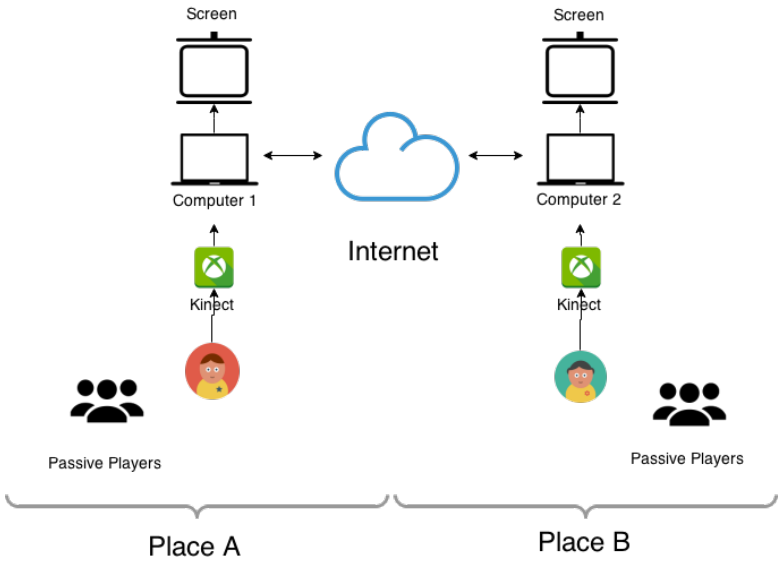

Figure 4.5: TNT Adventure's System Configuration

Chapter 5
TNT Experiment and Evaluation

5.1 Evaluation Method

TNT Adventure was carried out within a traditional kindergarten classroom that met the considerations needed to implement TNT Adventure. Once the classroom was configured, the children were allowed to play using the system. The children behavior thus observed using qualitative method. This includes a simple question and answer session with the children and observation. Thus, to understand the childrens behaviour, a video recording and screen recording were utilized.

Table 5.1: The Objective and Measurement of the Experiment

Goal	Measurement	Assessment Method
Encourage collaboration between children in remote environment	• Interaction between students. • Non-verbal cue using the motion capture device. • Capabilities of children in using motion capture device.	Observation, QA, and Video Recording

The component of evaluation consisted of the overall experience of the system, the visual and game play of TNT adventure, and how the participants collaborate during the experiment. The interview, video recording, and observation were done in the end of every experiment. Table 5.1 describes the objective and measurements of the experiments.

Since this research was done based on qualitative method, the objective is to understand how participant can collaborate using TNT Adventure system and in what way the collaboration is different from the other activities that can foster collaboration. In addition to the observation, lists of interview questions were

asked. The questions were given to the teacher and the teacher would ask the children because the children might be more familiar with the teacher rather than the author. Samples of the interview questions were:

- Do you like the game? What do you like about it?
- Do you find the game hard? Do you want to play again?
- What you don't like about the game

These questions may lead into more specific questions based on the respond of the children, for example, Do you get help from your friend, and so on.

Collaboration as well as education, is intangible. It could not be measured by numbers. Therefore a logic map is created to assess the TNT Adventure. The table 5.2 describes the evaluation logic for interaction principle.

Table 5.2: Evaluation Logic for Interaction Principle

Principle	How it is visualized and observed?
Interaction	• Negotiate if the players do not agree on the same option • Giving hints if the active players cannot play the game • Giving appreciations if the active players do well.

Table 5.3 describes the evaluation logic for enjoyment principle.

Table 5.3: Evaluation Logic for Enjoyment Principle

Principle	How it is visualized and observed?
Enjoyment of kinesthetic learning process through Kinect	• Maintaining attention (for10 minutes). • Facial expression (happy or confused). • Tones level.

Table 5.4 describes the evaluation logic for game play principle.

Table 5.4: Evaluation Logic for Game Play Principle

Principle	How it is visualized and observed?
Choose your own adventure game	• Understand the game as a whole. • Ability to play without adult's help.

5.2 Pre-evaluation: User Test in Fukuoka

The pre-evaluation was done in a kindergarten in Fukuoka, 23rd -24th February 2015. The figure 5.5 explains the participants of this pre-evaluation. The experiment was done in separate classrooms.

Table 5.5: The Pre-evaluation Participant

Age	Male	Female
4 years old	2	2
5 years old	3	3

The goal of the pre-evaluation experiment was to observed childrens understanding about Kinect and the childrens reaction towards TNT Adventure.

5.2.1 Design of Experience and Interaction

In the pre-evaluation experiment, the classrooms were configured according to the considerations needed to play the game. The configuration is described in the following figure. The distance between the player and the Kinect were arranged based on the Kinect range on normal mode. However, it is important to consider the childrens height when set up the Kinect distance. If the children were too short, the distance between the Kinect and the children need to be adjusted. Figure 5.1 shows the pre-evaluation system configuration.

The camera angle also needs to be considered. Since the pre-evaluation test was to observe the children behaviour, the camera should focus on the children. During the pre-evaluation, the assessment was done based on the video recording and observation only. A question and answer session was not conducted because the focus of the pre-evaluation experiment was to understand if the children were comfortable in using KInect and the game.

The experiment was conducted in two days. The first day participants were the children aged 5 years old and the second day participants were the children aged 4 years old. In the pre-evaluation experiment, the children were asked to play the Hidden Melody game only because of the time limit.

The children were divided into 2 groups of 3 children. One of them was playing as the active player and the rest of them will be supporting the active player as the passive players. When the active player finished the game, one of the passive players could swap with the active player. If the active player felt bored or lost

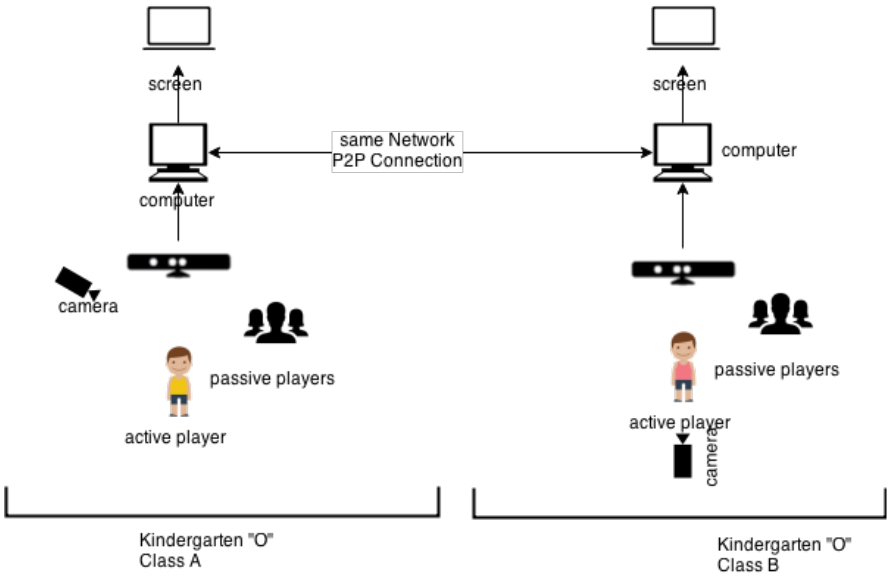

Figure 5.1: System Configuration for the Pre-evaluation

focus in the middle of the game, one of the passive players might replace the active player as well.

5.2.2 Evaluation

The observation method was done based on the childrens typical stages of development. According to Markopoulos, there are 3 features of children development:

- Physical development, which is generally associated with the size of the children, childrens movement skills, and childrens motor skills.
- Socio-emotional development, which is generally associated with the childrens relationship with other children and self-development.
- Cognitive development, which is generally associated with the intellectual such as their memory, their problem solving ability, and their reasoning.

Based on those features, a set of questions was considered to evaluate the pre-evaluation. The questions are listed in the table 5.6 below:

The first day pre-evaluation experiment took 1 hour for each group, with the details 30 minutes for the set up and 30 minutes for the actual experiment. Two to three teachers accompanied the children in each group. Before playing the game, the teachers told the children about what they were going to do. Because of the

Table 5.6: Issues to be Noted based on Developmental Features

Developmental Features	Issue to be Noted
Physical Development	• Is it physically and ergonomically possible for test participant to use the Kinect? • Is Kinect suitable for a specific age group?
Socio-Emotional Development	• Can a child cooperate in a way that is required when performing a test with another child? • Do the children have positive feeling about the experiment once its over?
Cognitive Development	• Does the children understand what they expected to do? • Are the task understandable and memorable • Can the children use the game independently • Can the children understand the written form?

time limit, the children only played the Hidden Melody and Bubble Pop and skip the story part. Figure 5.2 shows how the child played Hidden Melody game.

Figure 5.2: A child play Bubble Pop and was able to match the correct answer

Based on the observation, the result of the experiment is described in table 5.7

Table 5.7: Result of the Pre-evaluation

Issues to be noted	Measurement	Result
• Is it physically and ergonomically possible for test participant to use the Kinect? • Is Kinect suitable for a specific age group?	• Player can point on objects according to their own will.	• Children can point on objects up to certain level • Children aged 4 5 were able to use the Kinect.
• Can a child cooperate in a way that is required when performing a test with another child? • Do the children have positive feeling about the experiment once its over?	• Communication between children happened. • Children do not show confusion or frustration	• Children were able to support each other
• Does the children understand what they expected to do? • Are the task understandable and memorable • Can the children use the game independently • Can the children understand the written form?	• Children know the correlation between their movement and what happen in the screen. • Children seems focus and interested, and do not need the teachers help to solve the problem.	• Children were able to choose the correct answer by moving their limbs. • They can focus up to 5 minutes and did not depend on the teacher

From the pre-evaluation it can be concluded that the children were able to use the Kinect, however there were 4 major problems noted:

- If the children are too small or they move to fast, their movement might not be detected by the Kinect.
- Their hands in the game screen looked jumpy and uncontrollable several times. This problem might be fixed by changing a part of the code.

- It took several minutes for the children to understand the game and they looked confused.
- There were 2 hands displayed in the screen and the children looked confused because they did not know which hand belong to who.

From the cognitive and socio-emotional development perspective, it could be concluded that the children understood the game and what they were expected to do because they did not rely on their teachers when they were playing the game. However, the observer help was needed when the children could not control the hands movement.

Figure 5.3: A child got a correct answer thanks to the hints

Communication happened between the children. They were placed in separated classroom resulting that face to face communication could not be conducted. However the communication between active player and passive players happened. The passive players could be more engaged in the game by supporting the active player, as shown in the figure 5.3. The passive players also tended to gave directions to the active players. By adding additional screen, both active players and passive players were more engage in the game and they can kept their focus for quite a long time. Figure 5.4 illustrates the reaction between passive and active players.

Based on the evaluation, several improvements were made before conducting the first evaluation.

Figure 5.4: The reaction of Passive Players when the Active Player played

5.3 First Prototype: An International Kindergarten in Tokyo

The first-prototype experiment was conducted in Kindergarten B, an International Kindergarten in Tokyo. The test was conducted in the Kindergarten in Shibuya in 14th May 2015. The participant of the test is described in the table 5.8 below.

Table 5.8: The First Experiment's Participant

Age	Male	Female
4-5 years old	2	2
5 - 6 years old	1	1
3 years old	1	1

The test was organized into 2 sessions. The first session was conducted for the 4-6 year old children and the second session was conducted for the 3-year-old children. There were 3 major improvements made for the first prototype experiment.

- Instead of making the children playing the mini games only, in this experiment children had to follow the story. When they finished a story, they may make an agreement between themselves whether they want to replay the story or play the mini games.

- Several improvements in the back-end part to make the hands movement less jumpy.
- The mini-games Secret Garden game play was changed into turn-taking game play.

5.3.1 Design of Experiment

Because of the limited space of the school, the first experiment could not been done in two separate classrooms. The first experiment was done in a big multi function room in the school. A divided was installed to divide the room into two parts.

The interesting part about this school is they have implemented an interactive whiteboard as a teaching tool since long time ago. With this interactive whiteboard, a mouse click could be replaced with a touch to the surface of the whiteboard. Since the school already has an interactive whiteboard, one of the Kinect will be connected to the whiteboard and the other Kinect will be connected to a projector. Figure 5.5 describes the arrangement of the classroom.

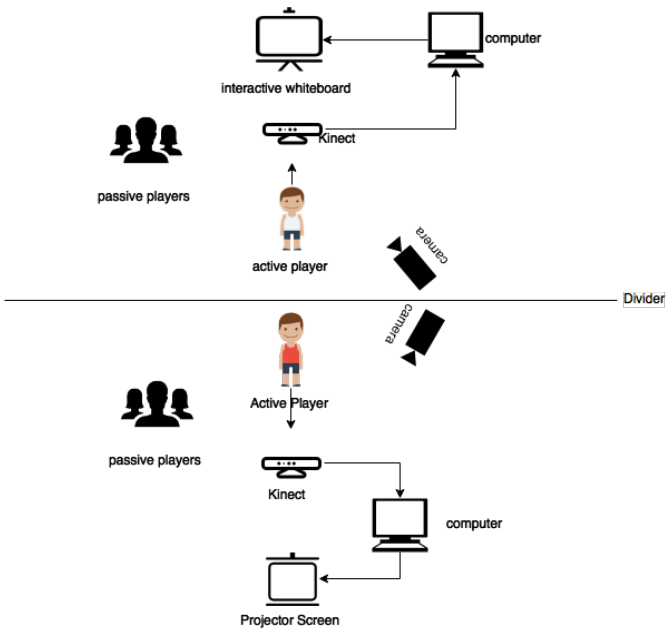

Figure 5.5: First Experiment in Kindergarten B Layout

At the first session, the children were divided into 2 groups based on their

age. The first group consisted of children aged 4-5 years old competed against the group of children aged 5-6 years old. This arrangement was made because the age gap was not that big. Those children were not originated from the same classroom, so the chance of them knowing each other or interacting with each other regularly was small.

At first, the instructor told the children about what they were going to do. The instructor also asked several pre-test questions like Have you seen this device before? or Do you know about X-box to test the childrens familiarity with the Kinect. After the pre-test, the instructor helped the children to practice with the avatar and one of the game to let the children become familiar with the Kinect.

The practice session was followed by the real experiment. First the children were asked to follow the choose-your-own-adventure story game and after they finished a story line, they were allowed to decide between themselves if they wanted to play another story or just skipped to the mini games.

Regarding the childrens cognitive level, the children were already able to read and write. The teacher explained the story and what happened in the screen, but the teacher did not do that in the whole time because the children were able to grasp the story by themselves.

Figure 5.6: A child playing Hidden Melody

After finished the story, because of the limited time, the children were agreed to skip the story and play the mini games. Figure 5.6 shows a child playing Hidden Melody. They chose to play the mini games Hidden Melody and Secret Garden. The last mini game could not be played because of the limited time. A small question and answer session ended the first session.

The group of 3 years old children attended the second session. These children were not able to read and write yet. Because they were too young, they played the story only. The second session was also ended by a simple question and answer session.

5.3.2 First Session Evaluation

A camera was installed for each group of children to record the children behaviour and reaction to game as well as their facial expressions and tones level. In addition to the camera, both computers also did the screen recording to measure the childrens ability to use the Kinect. At the end of the first and second session a set of questions were given to the teacher. The teacher then asked those questions to the children. The observers were not allowed to ask questions to the children because the children were not familiar with the observers and it may lead into biased answers. Those 5 questions are:

- Do you want to play again if you could?
- Is there anything you dont like?
- What is your most favorite part?
- Is it easy for you?
- Do you prefer the whiteboard or the kinect?

The qualitative research on the first experiment was done based on the logic map in the first sub section in this chapter. Table 5.9 shows the result of the logic map.

Related with the interaction principles, there were some actions that were expected to happen, but during the experiment, the result was far from the expectation. The negotiation did not happen during the experiment. The children did not negotiate with each other when they were trying to make a choice in the story. Figure 5.10 illustrates this condition. When player 1 had to make the choice, player 2 will try to express their opinion by shouting to player 1. However player 1 was too engrossed in their screen and they ignored the other player in the end. However, this system does stimulate a direct conversation and encourage the children to start a conversation and voice their opinions.

Table 5.9: The First Session Logic Map Result

Principle	Result
Interaction	Interaction between passive and active players are described in these following points: • Passive players tended to cheer the active player during the game regardless they came from the same team or not. • Passive players gave hints to the active players, sometime they shouted the answer to the active players. Figure 5.7 and figure 5.8 illustrates this interaction Interaction between active and active players are described in these following points: • Active player tend to follow each other. When they see there was a hand somewhere in the screen, they tended to follow the screen. They gave hints to each other through the hands icon in the screen. Figure 5.9 illustrate this interaction • Because the separator between children in quite thin, they tried to discussed their opinion by shouting.
Enjoyment of kinesthetic learning process through Kinect	• They can maintain their attention for 10 15 minutes. • Their facial expression did not show any distress, they looked happy, and sometimes confused because they were not familiar with the Kinect. • Children tended to speak in high tones.
Choose your own adventure game	Children understood about the story and the mini games. They were able to play with the system without much help from the adults.

Figure 5.7: Active player asked passive players

Figure 5.8: Passive players cheered and helped the active player

Figure 5.9: Active player gave hint using the icon

Figure 5.10: Active player was too focused on his own screen

When the children were asked if they want to play again, their answer were positive and enthusiastic. Eight out of eight children answered that they would like to play again because of these following 2 reasons:

- I can play together with my friends
- The game is tricky that it is challenging for the children and makes them want to try the game again.

The children expressed three points that they did not like about the game.

- I dont like the screen ignoring me. One of the children expressed her frustration when she could not control the Kinect according to her will.
- Sometime it was confusing for them to identify which hands belong to whom.
- Most of the children do not like the time limit, which is set for each mini games because they want to play longer.

Figure 5.11 is captured during the interview session.

Figure 5.11: The interview after playing the game

The childrens responds when they were asked if they prefer the Kinect or the interactive whiteboard varied. The responds are illustrated in the figure 5.12 below

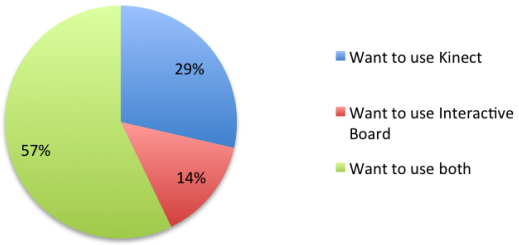

Figure 5.12: A graph illustrating children's preference

Most of the children said it is tricky to use the Kinect because it was their first time playing with the Kinect. However, the teacher added that this should not

be a problem because during the experiment there were adults who accompanied the children and helped them to readjust their position every time they were not detected by the Kinect. Figure 5.13 shows a child being helped by the instructor.

Figure 5.13: A child was helped by the instructor

5.3.3 Second Session Evaluation

The second session was not as smooth as the first session because the children were too young. They obviously did not understand what happened in the screen and how their movement was related with the game. They also did not understand what was the game about. Figure 5.14 shows that the child is too small to use the system.

It was difficult for them to interact with the Kinect. Their body sizes were to small that the distance and the Kinect position need to be readjusted several times. They muscle and motor skill were also still in early stage of development that it made it hard to coordinate the hands and eyes movement. They were also fast in losing their concentration. They were only able to concentrate for maximum 5 minutes. However, when the teacher asked if they liked playing game, the responds was positive. They said that their parents sometimes allow

Figure 5.14: Younger child showed a difficulty when using the system

them to play game in the cellphone or tablet. It shows that game might have a potential to help this children collaborate in some way.

Based on the result of the first and second session in B Kindergarten, some adjustments and improvements are needed before continuing to test the final prototype.

5.4 Final Prototype: An Indonesian Kindergarten in Tokyo

The first-prototype experiment was conducted in School S, an Indonesian School in Tokyo. The test was conducted in the Kindergarten in Meguro in 28th May 2015. The participant of the test is described in the table 5.10 below.

Table 5.10: The Final Prototype Experiment's Participant

Age	Male	Female
4 years old	3	2
5 years old	5	4

The 3-year-olds children were excluded from the experiment because the pre-

vious experiment shown that they could not use the system properly.

Table 5.11 describe the measurement of final prototype experiment.

Table 5.11: The Objective and Measurement of the Final Experiment

Goal	Measurement	Assessment Method
Encourage collaboration between children in remote environment	• Interaction between students. • Non-verbal cue using the motion capture device. • Capabilities of children in using motion capture device.	Observation, QA, and Video Recording.
Understand the relation between the game-play of each games and the collaboration	Each game plays encourage children to interact and collaborate in different ways	Observation

There were 3 majors improvements made for the first prototype experiment.

- Several improvements in the back-end part to improve the bubble pop game and fix the errors.
- The mini-games Secret Garden game play was changed into competition game play. Therefore all the games will have different game play and the relation between the game play and the collaboration can be tested.
- Visual wise, the character icons were added. Instead of the hand icon, now the player has hand and character icon. Player 1 will have Tata as their icon, and player 2 will have Taro as their icon. By using the idea, hopefully the player can recognize their hands without difficulty.

5.4.1 Design of Experience and Interaction

The experiment was conducted in two adjacent classrooms. The children were grouped into 2 groups based on their age. They competed with the 5-year-old children. This arrangement was made not only because of the gap is small, but also the children in 4-year-old group, most of them speak Japanese and the children

in the 5-year-old group speak Indonesian and a little bit Japanese and English. By grouping the children based on their language ability, an observation whether this game could overcome the language barrier problem.

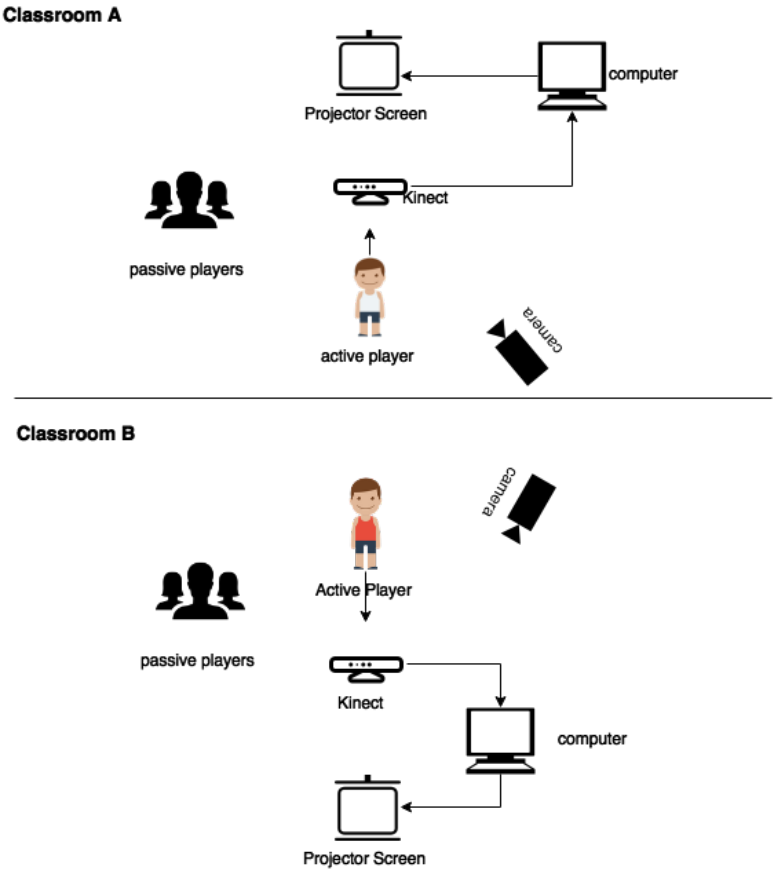

Figure 5.15: Classroom Layout

Figure5.15 illustrate the classroom's layout. In each room, a camera was installed to observed the children behaviour and reaction towards the game. A projector was also connected to the computer, so the passive players could see the game better.

Similar to the first experiment, this time the instructor also asked general questions to the children if they had seen Kinect or play with X-box before. Out of 14 children, only 3 of them had known about X-box and seen the Kinect, but they had never tried it before. This experiment was the first time for all of them to try the Kinect, therefore the session was started by a practice session. The

position of the Kinect and the distance between the children and the Kinect was adjusted. Then the children tried to move and match their movement with the avatar in the screen.

After the practice session, the real experiment began. The children played with the choose-your-adventure story. Unlike the children in Kindergarten B, the children here just started to learn to read. The teacher had to accompany them and explain the story to the children. They played the story for two iterations before they agreed to skip the story and play the mini games. They chose to play the mini games Hidden Melody and Secret Garden. The session was ended by a simple interview.

5.4.2 Final Prototype Evaluation

The evaluation was made based on the interview, the video camera recording, and the screen recording. The list of questions that was asked is listed below:

- Do you have fun or enjoy the game? Do you want to play again?
- What you like about the game?
- What you do not like about the game?

The qualitative research on the first experiment was done based on the logic map in the first sub section in this chapter. The forms of collaboration between children were quite similar with the previous experiment. The collaborations between passive and active players are explained in the 3 points below:

- Passive players helped the active player solving the mini games Hidden Melody. Instead of directing Up! or Left!, they tended to shout the correct answers like Seven! or This one! and pointed to the screen. Figures 5.16 illustrates this condition.

- Its OK, we could try 6 in the next turn, the passive players cheered the active player when they got a wrong answer. Figures 5.17 shows that passive players were more engaged.

- During the Secret Garden game, which is a competition style game, the passive players tended to cheer the active player for the same team. The children from the same team developed a same goal. Both active players also showed strong will to win the game, resulting a healthy competition between two teams.

Figure 5.16: A passive player gave answer to active player

Figure 5.17: Passive players were involved in the game

In this experiment, the children also improved their socio-emotional development. They learnt how to share with their peers and how to cave in. There was some point where the children became so curious with the Kinect and they swarmed in front of the Kinect (as shown in figure 5.18). The game could not run properly if there are a lot of children standing in front of the Kinect. Because there were a lot of children in front of the Kinect, the active player could not play and the game could not progress well. Knowing this, the passive players started to comeback to their seats without being told to.

Figure 5.18: Passive players tended to swarmed in front of the Kinect

As the visual had been improved in this experiment, the children even the children at very young age- were able to tell their icon precisely. According to the teacher, they just started to learn how to read and write, so it might be hard for them to follow the story and the teacher need to narrate the story. However, as the new visual also used the characters faces, Tata and Taro, as the icon and it made the children able to relate the game and the story. It could be inferred that using cute animal characters could attract children.

Figure 5.19: Interview Session

Figure 5.19 illustrate the interview session. Table 5.12 summarize the children's responds.

Table 5.12: Logic Map Result

Question	Respond
Do you have fun? Do you want to play it again?	7 out of 14 want to play it again. 3 out of 14 do not want to play again because its not challenging enough for them
What do you like about the game?	Most frequent answer is My first time playing a game like this., indicating they like playing while moving around.
What you don't like about the game?	Its hard. Sometimes I cant move

5.5 Discussion

Based on the 3 different user experience test, it could be inferred that there are several key features from TNT Adventure that could encourage children to collaborate with each other.

The first feature is the usage of Kinect and additional screen. From the observation, the children were able to concentrate and focus on the game for up to 10 minutes. Most of the children also have not used the Kinect before, thus it made them become more curious about the game. During these 10 minutes, children may find difficulties in using the Kinect. As they observe their peers who could use the Kinect better than them, they started to copy and teach each other. The passive players also increased their physical awareness so that they dont block the current player. The Kinect also help the children to communicate even if they did not share the same language, or even when the active players could not see each other. By moving their icon towards certain direction, active player could give a cue to the other active player to follow him. Players also moved the icon by learning or copying from the previous player.

Even if the Kinect might be quite tricky for the game, it helped the children to focus and it help the children to explore the game using their body. Players were curious and challenged, and it made them want to play the game again.

The usage of additional screen helped the passive players to understand whats going on with the game. They could see the game better thus they became more actively engage with the active players. The passive player could easily give directions to the active player, they could voice their opinion, and they could give support to the active player.

The second feature was the different game play of the mini game. It helped the children to explore the benefits of collaborating. For example, when they have to match the same answer, the player who already got the correct answer would tend to help the other player. By helping each other, player could proceed to the next question quickly. Not only the collaboration between active players, the active player could also collaborate with the passive player. When a group of children had to compete with the other group of children, the passive players in each group were rooting for the active players. They cheered the active players or even sometimes gave the answer to the active player. In this case, both active player and passive player developed a mutual goal, which is to win the game. This type of game play also helps the children to build a healthy competition.

The last feature would be the capabilities of playing with their peers. During

the interview session, a girl answered, I like it because I can play with my friends. when she was asked about what did she like about the game. TNT allows the player to play not only with their classmates, but also with another player whom they cant see. Probably they did not even know the other player. By combining the Kinect, the game play, and the collaborative environment, children could feel that they were the part of the game and they could enjoy the game with their peers.

Chapter 6
Conclusion and Future Work

The aim of this research was to illustrate how TNT Adventure may encourage children, especially kindergarten children and children who are not located in the same physical space. TNT Adventure uses an approach to the design of shared interfaces and motion capture device that had been observed to encourage children to explore the possibilities of collaborating, rather than forcing them to do so. By considering this approach, children should be able to work independently if they wish, but could discover that there are added benefits when they decided to work together.

6.1 Conclusion

From the fieldwork and the various settings in the 3 experiments, the fundamental principle for TNT Adventure can be concluded. With these principles TNT Adventure could bring an interactive learning environment into the traditional classroom. The children were able to collaborate and knew their peers better. Result from the qualitative research showed that children were stimulated to communicate with their peers, directly and indirectly. In addition, TNT Adventure was able to encourage both active and passive players to engage in the activities. Children from different backgrounds, languages, and skills may help and support each other through TNT Adventure.

From the result of the experiments, we can infer that full-body learning using the Kinect may help the children to focus and learn better. This was shown by the childrens attention span when they were using the system. Normally 3-5 years old children can only maintain their focus on certain activities that they like for a few minutes. However, during the test, children showed a positive behaviour and a longer attention span (up to 10 minutes). The Kinect provide an opportunity to explore the objects in the game using their whole body rather than just sitting

around. Kinect also support the children to train their motor ability and their hands and eyes coordination.

As for the gameplays, each gameplay type may result to different types of collaboration. A gameplay where the children were told to take turn allow the children to communicate their idea when the current turn player is about to make a decision. It also allowed the children to cheer up the players when they did not do well and gave appreciation when the players do well. In a gameplay where children have to match something in order to proceed, they learn how to share their skill and knowledge to their peers who face difficulties. A gameplay where children have to compete with each other help the children to build a healthy competition it direct the children to work together towards a mutual goal, to win. TNT Adventure had been observed to encourage collaboration between children regardless of the childrens physical location. Children still can use the system to collaborate when they were not located in same physical space (e.g different classroom, different school), and they still can use the system when they were sharing the same space, but different devices (two children using different Kinect and computer, but sharing a screen).

6.2 Future Work

From the result of the experiment, there are few things about the game that could be considered for adjustment. Some new features might also be added to the system to make the game more interactive for the children.

6.2.1 Content Adjustment

Children were a lot interested in playing the mini games rather than replaying the story to explore more storyline. This might be caused by several reasons. Children who were able to read may understand the story without the teacher had to retell the story. However, children who were not able to read might not understand the story. For the future works, when creating a choose-your-own-adventure game, it is better to use well-known story. Children might be more familiar with fairy tales or folklore and they may be able to follow the story if they already heard about it before.

In the current system, the mini games have a set of questions that has already been set. For example, in Hidden Melody, there are 7 country songs have already

been set and it will never change no matter how many times the children play. As a result, when children play it for several times, they might figure the pattern of the game and it will make the game become less interesting. Adding several levels and various questions will make the game challenging for the children.

The visual of the game might also be improved. The current system is based on 2D graphics. The characters have no voice and there animations are not smooth enough. Visual wise, a lot of improvement can be made. For example, in the current system, the avatar in the beginning of the game was made in skeleton version. Instead of the skeleton version, a full body of Tata and Taro might be more interesting.

When playing the mini games, some of the games do not provide an instruction or practice session. During the experiment, the instructor explained the rule of the game and how to play the game verbally. The instruction plays an important part of the game, however children who cannot read yet might not understand a written instruction. For the future works, an animated instruction or a practice session should be added in each mini games to allow the children use the system under minimum guidance from the adults.

6.2.2 Physical Awareness

Children who share same physical space might collaborate each other verbally. However the chance of collaboration between active players when they were not located in the same space was quite low. When the players were located in different physical space, they cannot communicate verbally. Therefore, adding a voice communication feature to the game might facilitate the children to communicate, especially if they were separated.

Installing an additional screen was considered as a good idea because the passive players were able to see the game clearly. If the passive players understood what happened in the game, they could actively engage in the game without bothering the active players. Hence, for the future works, the usage of additional screen should be sustained.

In order to play the game freely, it is suggested to play the game in spacious classroom. The kinect should be put in the table which height is suitable for the children.

6.2.3 Features Update

From the experiment, it could be inferred that younger children sometimes find difficulty when using the Kinect. Therefore, the usage of Kinect as the main input might be enhanced by the other input like mouse click. Kindergarten B implements the interactive whiteboard, which allows the children to touch the surface of the whiteboard as touching a tablet or touch screen. This may expand the possibilities of combining the Kinect with the other devices to enhance the interactivity.

Usually the boys find the game is not that challenging. It might be caused by the game play or the design. The current mini games and the character design might be modified or a new one might be added. A further research might be needed to find out what kind of game is suitable for a certain gender and what kind of game is suitable for all gender.

TNT Adventure usage also might be applied to older children (primary school age). TNT Adventure might also be applied in local environment where children are able to do face to face communication. A small experience was conducted before in a primary school. The children were grouped into 2 groups and each group played with a Kinect. The children were sharing the same screen and played the game in the same classroom. Based on the simple test, the primary school children showed great interest to the game. They also were able to play the Kinect without any difficulties. Because they were older, it was easy for them to figure out how the Kinect worked and where to position themselves. The children also showed more various collaborations. They were able to negotiate when they did not agree on the same choice and they were also able to mimick the other players. However, the level of the game makes it become too easy for primary school children. They got bored once they knew the pattern of the game. From this simple test, it could be infered that the Kinect and TNT Adventure have a great potential to be developed to broader age range and situations.

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"Education is not a preparation for life; education is life itself." - John Dewey

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