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Examining the Effect of Playing an Arithmetic-based Game- "Chopsticks" on the Arithmetical Competencies of 5-year-old Children in Singapore

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Abstract. In this study, the authors examined the effect of playing an arithmetic-based game- "Chopsticks" has on young children's arithmetical competencies. A total of 21 young children (Mean age: 4 years 11 months) from two typical early childhood settings in Singapore were randomized to an experimental group (n=10) and a control group (n=11). Those in the experimental group attended the learning and playing sessions of "Chopsticks" for a 4-week period, while those in the control group did not attend. All participants were administered with a Pre-test and post-test, which comprised 10 simple addition items each. The statistical results revealed that both groups of children performed at the same level in the pre-test. However, after the 4-week playing session of "Chopsticks", children in the experimental group managed to solve more items and utilize a shorter time to solve the items than children in the control group. Therefore, the authors suggested that playing "Chopsticks" enhances young children's arithmetical competencies.

Keywords: "Chopsticks"; arithmetical competencies; learning; early childhood settings

1. Introduction

In recent years, the issues involving the relation between children's early mathematics skills and their later mathematical competencies have been studied extensively by numerous researchers (Chu, vanMarie and Geary, 2015 ;Classens and Engel, 2013; Duncan et al., 2007; Franzen, 2015; Jacobi-Vessels, Todd Brown, Molfese and Do, 2016; Manfra, Dinehart and Sembiante, 2014). For instance, in Duncan et al (2007)'s study, 6 longitudinal data sets were used and analysed to determine the relationship between school readiness (academic, attention and socioemotional skills), and children's school reading and mathematical competencies in their later stage. All 6 studies revealed that the early

mathematics skills (one of the studied academic skills) emerged as one of the strongest predictor of young children's mathematical competencies in their later stage. Similarly, Manfra, Dinehart and Sembiante (2014) also stressed the importance of early mathematics skills as their study revealed that there is a strong link between children's early mathematics skills and their achievements in mathematics in later stage.

Together, all these studies have yielded convincing insights for us to believe how crucial the early mathematics skills has on children's mathematical development. Therefore, it is an aspect that we should not fail to take into consideration in any form of research involving mathematical development or cognition. As we can now understand the importance of early mathematics skills, this leads us to another important issue on how young children acquire and develop their mathematics skills during this crucial period.

As a matter of fact, children are innately endowed with a certain level of mathematics skills (Antell and Keating, 1983; Wynn, 1996), and these skills are usually enhanced and developed as the children are participating in different forms of activities with other individuals in their communities (Guberman, 2004; Ong, in press; Rogoff, 2003; Sakakibara, 2014; Saxe, 1991). Among these activities, young children spend a considerable amount of time playing various types of games, such as board games, card games and sports games, with their parents at home and their teachers and peers in early childhood settings. Though playing games is often perceived as a leisure or recreational activity (Ajzen and Driver 1991; Shawn and Dawson 2001), the past studies had reported that children tend to acquire and develop different types of mathematics skills from games which often contain some forms of mathematics (Early et al. 2010; Gerdes, 2001; Ramani and Sielger 2008). Considering such, having young children engaged in games plays a much more vital role in young children's mathematical development than we thought to be.

2. Playing games and mathematical development

Over the years, researchers have been investigating on how playing games benefits young children's development, especially in the area of mathematics (Barta and Schaelling, 1998; Bragg, 2003; Cutler et al. 2003; Gerdes, 2001; Ramani and Sielger, 2008). For example, Peters (1998) reported that 5-year-old children who played mathematics games with parental supervision, improved more than their counterparts who did not play the games, in the areas of number sequence, number patterns, and enumeration. Furthermore, Ainley (1990) and Bragg (2003) pointed that games often occur in a more meaningful context, thus they are more likely to attract the attention of the children. For this reason, the learning of mathematics through games tends to be a better and more effective mean in motivating children as compared to other means of learnings, such as rote learning or practising mathematics worksheets.

Despite there being large literatures that examine the benefits of playing games have on the young children's basic numerical skills, such as numeral identification, counting, and estimation (Barta and Schaelling, 1998; Cutler et al,

2003; Gerdes, 2001; Ramani and Sielger, 2008), arithmetic skills has seldom been the issue of similar investigation. It should not be overlooked as it serves as a foundation for the development of addition and subtraction, which is one of the most essential and important skills required when children proceed to elementary schools (Jordan, Kaplan, Ramineni, and Locuniak, 2009). Furthermore, the skill is also very important to young children as they often use it to solve different problems in their everyday lives (Bjorklund & Rosenblum, 2001; Sakakibara 2008).

Yet, to our knowledge, a dearth of studies, that centred on young children's arithmetic skills in the context of playing games, only examined the developmental and contextual effects on young children's addition strategies in playing board games (Bjorklund and Rosenblum, 2001; Bjorklund, Hubertz and Reubens 2004). However, these studies rarely examined the effect of playing games has on young children's arithmetic skills empirically, especially their arithmetical competencies, and this can be a piece of vital information for the educators when they design the curriculum for young children in the early childhood settings. Therefore, this is an area that we should not overlook and it is worth investigating.

In view of these considerations, the purpose of this study is to explore whether by playing an arithmetic-based game - "Chopsticks" will improve the arithmetical competencies of young children in Singapore.

3. "Chopsticks"

In our pilot work for this study, we found that "Chopsticks" is one of the most popular games in Singapore as young children are often seen playing the game with their peers during their play time, meal times and even during the intervals between lessons in many early childhood settings.

"Chopsticks" is basically a hand game which is commonly played by two players, and each player has to use both hands. It requires the players to possess at least some arithmetic skills in order to play the game. The number of extended fingers on each hand will represent the number of points the hand has. The hand with all five fingers extended will be considered as a "dead hand". Therefore, a player who has extended all fingers on his both hands loses the game.

Both players start the game with one extended finger on each of their both hands which resemble a pair of chopsticks. The players take turns to tap their opponent's hand. The number of points on the tapping hand will be added to the points on the tapped hand, and the tapped player will extend the added points to show the new score. The tapping hand remains at the same points. The player can transfer points from one hand to the other by tapping his own hand. For example, if he has one point on his left hand and three points on his right hand, he can tap his own hands to rearrange the points into two points on each hand, this is also known as splitting.

As we have explained the method of playing "chopsticks", it is clear that the

players have to calculate and monitor the points on their own and opponent's hands continuously to avoid the "dead hand". For this reason, children playing "Chopsticks" are likely to use more arithmetic skills than that of other extensively studied games such as, "Chutes and Ladders", and "Checkers". This can also suggest that playing "Chopsticks" may have a greater effect in enhancing the arithmetical competencies of those young children who play it on a regular basis. This also explains why we have selected "Chopsticks" in our study. In order to establish the effect on young children's arithmetical competencies, we will be comparing the test results and the time taken to solve problem of those 5-year-old Singaporean children from the experimental and control groups in their pre-test and post-test. The details of the study will be discussed in our next section.

4. Methodology

4.1 Participants

A total of 21 young children (10 girls, 11 boys), who were ranging from 4 years 9 months to 5 years 3 months in age, and had no knowledge of "Chopsticks" from two typical early childhood settings in Singapore were selected as participants. They were randomly assigned to two different groups: experimental and control groups. These children were selected instead of those who already knew the game, as it would be difficult to determine the effects of playing "Chopsticks" had on those who know the game since they had different levels of exposure to the game prior to the study. For this reason, we only selected those who had no knowledge of "Chopsticks".

10 Children in the experimental group were taught how to play "Chopsticks" while the remaining 11 children were in the control group. In other words, only the children in the experimental group learnt and played "Chopsticks" in this study.

Before the study, all participants were tested to ensure that they had the ability to count to 10 and performed simple addition problems. 25 children were tested, and 23 met the criteria. We had further removed two children from the control group as we discovered that they had learnt to play "Chopsticks" from their peers during the course of our 4-week study. Therefore, we had 21 children participated in this study.

The researchers had obtained both informed consent from parents and assent from children prior to the study. These were voluntarily provided by parents and children without feeling any pressure to accede to be involved in this study. Procedures and items in the study were slightly modified to eliminate any potential stress in children. In addition, all children were given the opportunity to withdraw from the study at any time, and all their information are treated confidentially.

4.2 Instruments

Individual addition-based tasks were used to assess the children's arithmetical

competencies before and after playing "Chopsticks", namely the pre-test and post-test, respectively. The similar tasks were also administered to the children in the control group.

The pre-test included 10 addition items with sums less than 10, and consisted of only addends 1 to 4, which corresponded to the possible addends during the game. The items in post-test were identical to those in pre-test, however the items were arranged in different sequence. Details of the pre-test and post-test items are shown in Table 1.

Table 1. Descriptions of the Pre-test and Post-test items

Pre-test	Post-test
1+1	2+1
2+1	2+4
1+4	1+4
3+3	2+2
2+4	3+3
3+1	3+1
2+2	4+3
4+3	1+1
4+4	3+2

4.3 Procedures

4.3.1 Pre-test and post-test

Pre-test was administered prior to the learning session and playing session, and post-test was administered at the end of the 4-week playing session.

The children were seated at a low-lying table directly facing the researcher and were tested individually in a quiet study room. All the 10 pre-test items and 10 post-test items were read out one at a time to the children, and they were told to verbalise their answers to the researcher. After the test, the children were asked

to wait in another room till all the children had finished the tests. By doing so, we can ensure that those children who had finished the test will not have the chance to discuss the problems with those who had yet to do the test.

4.3.2 Learning session

10 children in the experimental group first attended three learning sessions to learn how to play "Chopsticks" in two groups. In each 15-min session, the children sat on the floor facing the researcher as he explained the rules and ways of playing "Chopsticks" to the children. All children had a chance to practise playing "Chopsticks" with the researcher. In order to ensure that all children were able to play the game, the researcher played the game with each child for 5 minutes after the three learning sessions. All 10 children did not have difficulty in comprehending and playing the game, and proceeded to the playing session.

4.3.3 Playing session

All children in the experimental group attended the playing session in pairs for 15 minutes thrice per week over a 4-week period. In order to make the playing session similar to the natural setting of playing games in the early childhood setting, the children played "Chopsticks" with their peers instead of with the researcher. However, they played the game in the presence of the researcher in a quiet room, while the researcher sat beside each pair ensuring that they played only "Chopsticks" and guided them if need arose, during each 15 minutes session. The children attended the playing session in a pair at a time.

4.3.4 Control group

11 children in the control group were excluded from the both learning and playing session. The researcher had also conducted weekly individual interview session with each child to ensure that they did not get to learn "Chopsticks" during the course of the 4-week study. During the weekly interviews, the researcher asked these children questions such as had they heard of the game "Chopsticks", did they know how to play the game, and did anyone teach them how to play the game recently. Through the interviews, two children revealed that they had recently learnt "Chopsticks" from their peers and they were removed from the control group.

4.4 Independent variables

The arithmetical competencies of the children were determined by the two independent variables- children's test scores (pre-test and post-test), and their time taken to solve problem in this study.

Firstly, the total scores of pre-test and post-test items for each child were measured. One point was awarded for each correctly solved item, with a maximum of 10 points.

Secondly, the time taken to solve each item correctly was measured in seconds by the researcher. He started the stopwatch when he presented an item and stopped it when the children answered. According to Bull and Johnston (1997), one is likely to take a shorter time to solve easy arithmetic problems.

We expected that, due to the effects of playing "Chopsticks" have on the children's arithmetical competencies, the children in the experimental group will tend to achieve a higher score and require a shorter time to solve the items in their post-test than in their pre-test. We also expect this group of children will perform better in the 2 variables than the children in the control group in the post-test.

5. Findings

5.1 Test Scores

The control group's children scored an average of 6.18 out of a total of 10 for pre-test items, and an average of 6.27 out of a total of 10 for post-test items. Conversely, experimental group's children performed better in post-test items than pre-test items, with an average score of 7.40 and 6.20, respectively (Figure 1). Two way factorial analysis of variance (ANOVA)'s results showed that there was a significant Groups' test scores × Test types interaction, F (1, 19) = 6.61, p< .05. In addition, simple main effect tests were also performed to determine statistically whether the test scores of experimental group's children and control group's children differed across the_test types. The statistical analysis revealed that the effect of the test types for the experimental group is significant, F (1, 19) = 14.78, p< .001. However, the effect of the test types for the control group is not significant, F (1, 19) = 0.09, *n.s*.

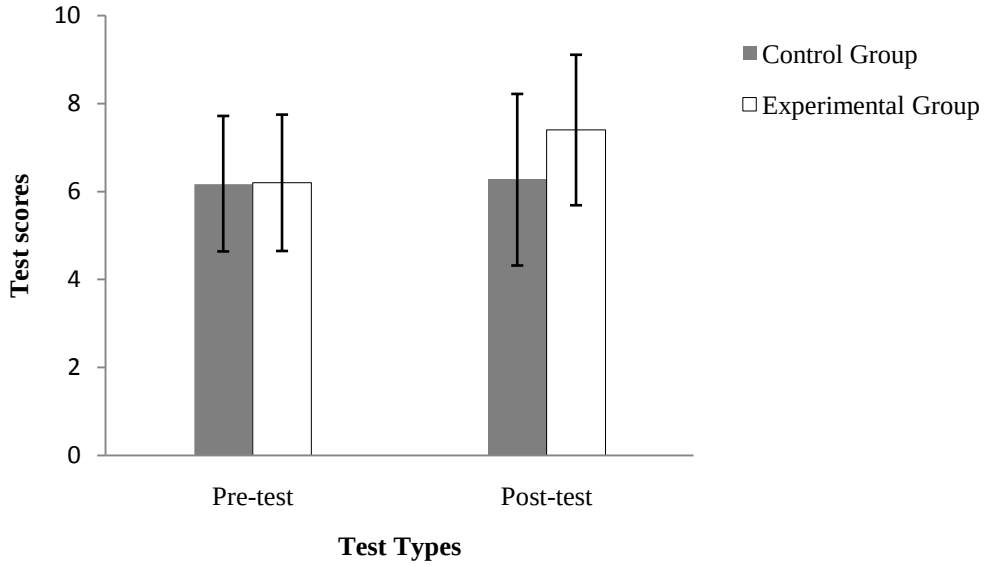

Figure 1. Test scores over the test types

In view of these results, it is evident that playing "Chopsticks" had resulted the children in the experimental group to solve more items correctly in the post-test than in the pre-test. In contrast, children in the control group, who did not play the game, had similar pre-test and post-test result.

5.2 Problem Solving Time

Control group's children took an average of 3.12 seconds and 3.30 seconds to solve pre-test and post-test items, respectively. In contrast, experimental group's children's solving time for pre-test and post-test items were 3.23 seconds, and 2.00 seconds, respectively (Figure 2). Two-way factorial analysis of variance (ANOVA) was conducted, and there was a significant Groups' solving time × Test types interaction, F (1, 19) = 15.97, p< .001. In order to statistically determine whether both groups' children's solving time differed across the types of tests, simple main effect tests were also conducted. The statistical analysis revealed that the effect of the test types for the experimental group is significant, F (1, 19) = 23.28, p= .001. In contrast, the effect of the test types for the control group is not significant, F (1, 19) = 0.53, *n.s.*

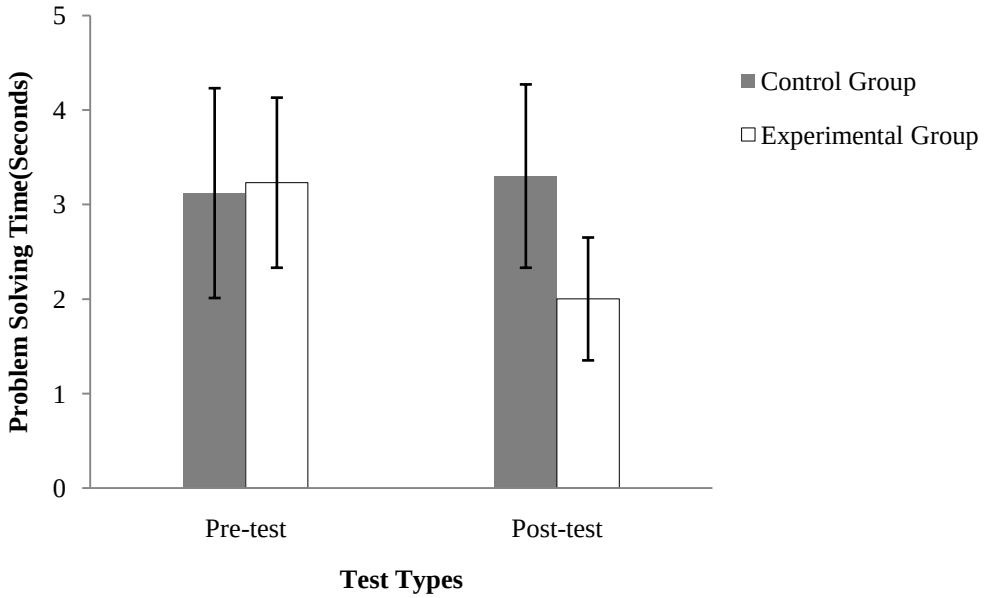

Figure 2. Solving time over the test types

In view of these results, there are good grounds to believe that playing the "chopsticks" games had resulted children in the experimental group to solve items faster in the post-test than in the pre-test. On other hand, there was not much difference in the problem solving time between the pre-test and post-test of the control group's children.

6. Discussion

This study is the first to examine whether playing the arithmetic-based game-"Chopsticks" will enhance the arithmetical competencies of young children. Our findings add to the existing literatures, that support playing games has positive impacts on the development of children's early mathematical achievement (Cutler et al, 2003; Griffin, 2004; Klein and Starkey, 2004), by revealing the improvement of young children's arithmetical competencies when they played the "Chopsticks" on a regular basis during our 4-week study.

In fact, before the "Chopsticks" was introduced to the children in the experimental group, they performed almost on par with those in the control

group, in terms of average test scores and problem solving time in the pre-test. In other words, children in both groups, on average, had near identical level of arithmetical competencies at the beginning of the study. However, the distinct differences between the two groups set in during the post-test stage, when the experimental group's children who learnt and played "Chopsticks" in this study tend to solve more addition items and solve the items faster as compared to their own pre-test's results and their counterparts in the control group. Taking into consideration all the data from both groups' children, there are good grounds to believe that playing "Chopsticks" have yielded improvement in young children's arithmetical competencies. However, how does playing "Chopsticks" enhance young children's arithmetical competencies?

As mentioned earlier, compared to other popular games such as, "Chutes and Ladders", and "Checkers" (Ramani & Siegler, 2008), "Chopsticks" requires the players to possess not only a higher level of arithmetic skills but also use more arithmetic skills. This is especially true because the players in each pair need to calculate and monitor the points on their own and opponent's hands continuously, as the points will change after each tap during the playing session. In other words, each player has to solve addition problems, with addends between 1 and 4, in a relatively fast speed, in order to keep up with the pace of their opponent and continue the game. Therefore, having to learn and play "Chopsticks" over the period of 4 weeks had led the children in the experimental group to develop the ability to solve more addition problems and at a faster speed which were reflected in our findings. Conversely, the arithmetical competencies of those children in the control group remained unchanged throughout our study.

7. Implications

These findings are beneficial for Singapore's early childhood educators and parents by providing insights into the effect of playing "Chopsticks" has on the development of arithmetical competencies in Singapore young children. Based on the findings, it has become more apparent for parents and early childhood educators in both Singapore and other countries which place strong educational emphasis on the assessment of learning and formal lessons (Ong, Kawata and Takahashi, in press) to understand that playing games does also play a vital role in the development of young children's arithmetical competencies besides academic based activities. In addition, playing games has also been reported to be more effective than other means of learning as games often occur in a more meaningful context, which in turn motivates children to learn (Ainley 1990; Bragg, 2003; Cutler et al, 2003). This may also help to raise an even higher awareness among early childhood educators about the importance of including more arithmetic-based games in their early childhood curriculum to make learning mathematics more interesting and easier for the children.

Further, apart from other popular board games, such as "Chutes and Ladder" and "Checkers", the "Chopsticks" can be an alternative game which early childhood educators may be suggested to add into their curriculum for mathematics learning. The "Chopsticks" tends to have greater advantages over

most of the other games as it only involves the use of hands. Thus, educators can teach the young children arithmetic with this game easily and conveniently without the use of any other material besides their hands.

8. Limitations and Future Research Directions

Similar to other studies, this study also has some limitations. For instance, this study only examined a relatively small number of young children in Singapore, and this might not generalise the results. Therefore, a larger sample size of children is required for future studies. In addition, this larger sample size shall comprise children of different age groups, since previous studies, which centred on other games, such as "Chutes and Ladder", have reported that due to the process of mathematical development, children across age groups tend to play the game differently. For instance the use of different types of addition strategies (Bjorklund & Rosenblum, 2001). Therefore, by examining children in the different age groups playing "Chopsticks" may unfold other issues relating to the effects of playing games have on the development of young children's arithmetical competencies.

Next, the players only deal with addends from 1 to 4 in the existing "Chopsticks". However, young children deal with more than just addends ranging from 1 to 4 in their everyday lives. For this reason, future studies may want to modify the game of "Chopsticks" in such a way that more and higher-digit numbers can be included into this game. And by doing so, the benefits of playing "Chopsticks" will be even more applicable to the everyday lives of young children.

As mentioned earlier, this is the first study to examine the effect of playing "Chopsticks" has on young children's arithmetic skills, especially in the area of competencies. Therefore, it lays a foundation for other future studies not only investigate deeper into the relation between playing "chopsticks" and young children's arithmetical competencies, but also uncover other potential issues involving the development of young children's arithmetic skills, which remain to be unanswered by other previous studies that centered on those extensively studied games. Hence, this is may be another area which is worth investigating in future studies.

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