



Preschoolers' Mathematics Game Preferences and Learning Performance through Designing a Degree of Freedom for a Tablet Game

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Abstract

Children always have a natural inclination to play, so the purpose of game-based learning is to establish a way for children to acquire knowledge while playing. This study is to discover the relationship between children's play preferences and learning performances toward a mathematics mobile game we designed. The tablet game we designed, "Lily's Closet", is a mathematics game that guides children aged 3-8 to learn "classification". To explore the preferences and learning performances of the games we designed for the preschool children, we put "Lili's Closet" on a children's tablet named Kizpad with over 200 games. We classify and analyze players' behavior data by Data Mining in our designed game to explore children's play behaviors and preferences. We sampled 6,924 children from Taiwan, aged 3-8 years old. In the results, we found that there is a significant difference in the number of ages and achievements in the game. The maturity of the child's age is positively correlated with the achievement of the game, but it is negatively correlated with the number of times of willing to play. As a result, we suggest that to assist learning, we should give children different levels of games according to their ages. The research hopes to resonate with readers and jointly explore the relationship between mobile games.

Keywords Early childhood education · Game-based learning · Age preferences · Learning performance adaptive development

1 Introduction

In the state after the Covid-19 period, we all face the challenge in education that online learning or learning at home may be a "new normal" in the upcoming years. Unlike in the past, parents nowadays are more likely and also need to spend time

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with their children at home, and home is where early childhood education begins. However, since the Covid-19 situation is the new normal world, in the education field, we need to look for a new solution to encourage children's learning autonomy that can not only lower parents' burden of teaching but also connect to school education. According to reports, during the quarantine period, children have fallen the learning progress for three months, and children with parents who have lower education can lose learning opportunities by at least 50% (The Economist, 2021). Education in early childhood is especially about critical timing for development. Once any lockdown situation happens again, we need to prepare new ways of teaching material for children.

"Games Generation," which is also called the "G Generation," is a group of people who learn differently by playing computer games (Prensky, 2001; Gibson et al., 2007). Digital games and the internet stimulate interactive effects. Gamers are motivated to learn and achieve learning goals on gaming factors, such as sound effects, fantasy, competition, and rewards. (Prensky, 2007).

Research shows that children like to play games continuously because games are fun, exciting, and challenge them to solve problems. (Gerkushenko & Gerkushenko, 2014; Dalton & Devitt, 2016). More research suggests games make children feel independent and capable (Godwin et al., 2015; Mouws & Bleumers, 2015). In-game scenarios, children "enjoy" the stimulus if they can feel they are capable of coping with challenges (Gerkushenko & Gerkushenko, 2014; Dalton & Devitt, 2016).

We know that games are important for children, and we also know that mathematics ability is an important foundation for early childhood development (Hunting, R., 2010). Therefore, we should think about: 1. How to combine mathematics and games? 2. Children of different ages have different learning needs. Are there any differences in mathematics learning in our designed game? In response to the above problems, our research hopes to discover the trend of children's digital game-based learning (DGBL).

Children learning mathematics through games is what we want to explore in our research, but we want to find out whether children of different ages have different preferences for the games we design. In this research, we have designed a math "classification" game, "Lily's Closet". We hope to transform this life into a digital game experience, and we can observe the children's achievements and preferences for this game through big data analysis.

Young children may have problems completing paper-and-pencil questionnaires or tests, so it is necessary to utilize Data Mining to analyze players' behavior within the "Lily's Closet" application on the Children's tablet. Data Mining can structure big data and classify databases relevantly. We apply the five stages of "the knowledge discovery in databases process" (Fayyad et al., 1996) to explore if children can repeat one game again and again.

Many previous studies in the field of children's learning showed that "digital games" can assist the learning of mathematics. Gaming can make children improve their learning motivation and learning effects (Aunio & Mononen, 2018; Käser et al., 2013). However, few studies explore how it works on children. We aim to explore the relationship between preference and flow to determine whether a strong preference for games leads to high levels of flow and

improved learning outcomes when children are given greater freedom to choose their activities.

1.1 Study Questions

Our study questions are as follows:

1. What is the difference between children’s gaming behaviors and the learning effect between kids who are highly involved in DGBL and kids who are not?
2. What is the relation between age and gaming frequency?
3. What is the relation between age and the learning effect?

As we convey above, to have a more in-depth discussion, the following will discuss each aspect of the research in the theoretical structure.

2 Theoretical Structure

The research structure is based on Digital Game-based Learning (DGBL), the Flow State theory, and works of literature on children’s math learning. To avoid children from game addiction, we contained the protective restriction design in the game. Our theoretical structure is as follows.

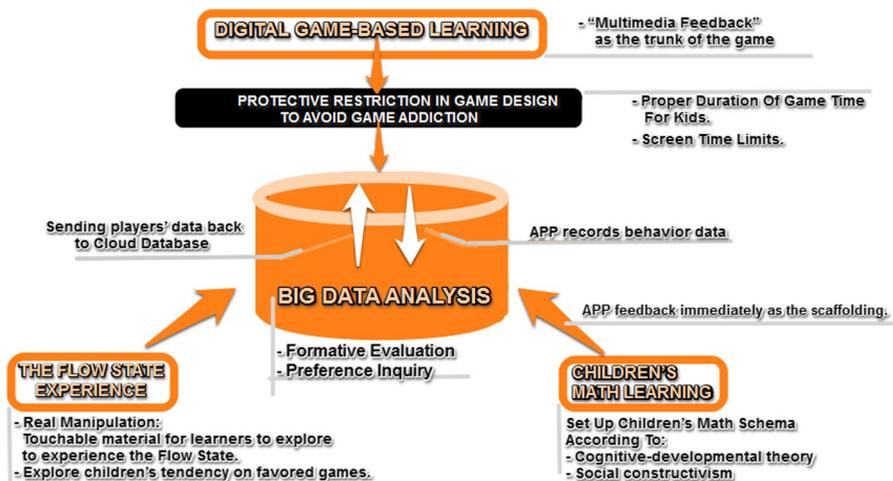


Fig. 1 Theoretical Structure

We aim to investigate young children's learning outcomes and game preferences through big data analysis, as shown in Fig. 1. To achieve this goal, we analyze children's flow experiences to understand their game preferences, evaluate their mathematical learning outcomes through game-based learning, and design a digital tablet game to foster their self-directed learning. In addition, we have established protective mechanisms to prevent excessive game use and protect children's well-being. Therefore, the central point in Fig. 1 is big data analysis, which encompasses game-based learning, flow experience, and mathematical learning for young children. In the following sections, we will elaborate on each of these dimensions.

2.1 Digital games and children's autonomous learning

Digital game-based learning (DGBL) is a kind of game that defines learning outcomes and involves game rule design. GBL's philosophy believes that if we can stimulate children's enthusiasm and let them develop a sense of learning, children will automatically learn and acquire knowledge and information (Van Eck, 2006).

Based on studies conducted by Käser et al. (2013), Godwin et al. (2015), Mouws & Bleumers (2015), Dalton & Devitt (2016), Aunio & Mononen (2018), and Gerkushenko & Gerkushenko (2014), it has been found that Digital Game-Based Learning (DGBL) can improve children's attention and learning motivation, ultimately leading to better learning outcomes. However, there are pros and cons to digital tools. If digital games are not designed for learning purposes, and if facilitators such as parents and teachers do not teach children how to use digital products properly, games may harm children's cognitive development or lead to false perceptions (Lieberman et al., 2009). DGBL is a must-have learning trend now, so designing a well-designed game to help children's development, hobbies, and abilities is an important task for future human beings.

"Lily's Closet" is a game that we created to explore its potential for inducing flow and promoting learning outcomes (Csikszentmihalyi, 1975, 1990 & 1998). To achieve this, we have integrated big data (Fayyad et al., 1996) into the game mechanics to assess whether our design aligns with the principles of flow and learning for children. In this game, mathematical concepts are introduced through everyday scenarios of tidying clothes, which are grounded in children's categorization abilities and developmental processes. By doing so, we aim to provide a meaningful and engaging learning experience for children.

Our study was conducted in collaboration with Kizlab, a company that produces the Kizpad - a tablet designed for children. The Kizpad features over 200 children's games. In this study, we analyze children's game behavior using big data, which includes their ability to operate games independently, the frequency at which they repeat playing the same game, their ability to complete in-game tasks, and the number of stars they earn, among other related metrics. Therefore, the design of this research is in line with children's self-learning ability, observing children's conditions at any time, and giving enough freedom for children to choose other interesting games.

2.2 Protective Restriction in Game Design to Avoid Game Addiction

The game utilized in this study has been designed to prevent addiction to DGBL among children. Research has indicated that digital games can have adverse effects on children, such as damaging their interpersonal relationships and hindering their ability to learn effectively. However, some scholars argue that it is essential to cultivate a wealth of technological literacy in early childhood and integrate digital games into other activities without replacing activities that involve young children's large muscles and limbs. Therefore, other indoor or outdoor activities cannot be sacrificed (Kalas, 2010).

As we convey above, there are pros and cons perspectives to children's use of digital technology. In 2015, the Taiwan government stipulated the Recommendation of Warnings for Using Electronic Products from the Health Promotion Administration, Ministry of Health and Welfare" to "remind business owners and parents to care more about visual health of their children, particularly with regards to the use of electronic products and visual health". The Recommendation regulates business to label warning sign as "rest your eyes for 10 minutes after using the electric products for 30 minutes" (Health Promotion Administration, Ministry of Health and Welfare, 2017). Therefore, our game is designed for less than 3 minutes, and the screen is forced to shut down every 30 minutes to help children to rest their eyes. Therefore, this research also carried out the game mechanism of resting every 30 minutes in our game design.

2.3 Children's mathematical development and game design

The games in our study were about children's early mathematics learning. Our research is based on Piaget's theory of cognitive development and Vygotsky's socio-cultural theory.

Cognitive-Developmental Theory explains how children develop their knowledge of the outside world, the basic elements of development are called schemas (Piaget, 1952; Hunting, 2010). Piaget stated that the establishment of cognition is an active process (Crain, 2014; Herczeg et al., 2019; Bhattacharjee, 2015) based on prior knowledge. Children encounter cognitive conflicts in the process of interacting with the world, adapt to conflicts through assimilation and adaptation, and establish new cognitions (Piaget, 1962).

Our study participants were pre-operational children aged 3-8. The cognitive thinking of children in the preoperational stage is fixed and concrete; for example, they can read simple symbols but cannot think logically. When their cognition develops to the next stage, the stage of concrete operations, they can reason and think in terms of concrete things.

Games are how children learn new things (Piaget & Inhelder, 1969). There are many ways to game-play, such as symbolic play or pretend play, differentiating reality and fantasy, role-play, personification in the story, and perspective-taking (Edna & Ronny, 2015; Woolley & Ghossainy, 2013; Yadi, 2020). Piaget believed that children will adapt themselves to the game through the transformation function, absorb

new experiences, and acquire knowledge. For children of different ages, with different stages of cognitive development, the content and form of the game will also change, so that they can continuously construct and develop themselves in the game (Piaget & Inhelder, 1969).

Play materials are also a source for young children to acquire mathematical concepts (Hunting, 2010; Piaget, 1962). Piaget (1962) pointed out that children construct mathematical concepts through hands-on play to explore and develop knowledge of objects and logical relationships. Individuals participating in activities acquire knowledge, and then gradually accumulate and build cognitive concepts (Piaget, 1962). Therefore, for children, the manipulation and repetition of games is an important behavior for learning mathematical concepts.

According to *Social Constructivism*, Vygotsky's "Zone of Proximal Development (ZPD)" suggests that there are two levels in children's development (Vygotsky, 1978): the actual developmental level and the level of potential development. ZPD is "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978; Wang & Cook, 2017). Vygotsky believed that every child has unique actual abilities and ZPD, thus requiring tailored guidance and assistance through a process known as "scaffolding."

The scaffolding provided in this digital game includes various features such as instructional videos, animated prompts that guide players on how to play, and audio cues such as ticking sounds that signal if the player is taking too long to complete a task. These scaffoldings in the game guide children to comprehend and imitate so that children can absorb and internalize to develop a higher level of cognition and acquisition capabilities.

Therefore, based on the above theoretical analysis, the "Lily's Closet" developed by the game developer in this study meets the following characteristics

1. Give children scaffolding in the game, such as: prompts, guiding animations, etc.
2. Give appropriate question sets in the game: We provide multiple question sets. When children make consecutive mistakes, in addition to giving hints, we will also reduce the difficulty of the game so that children can play the game according to their learning progress.
3. The classification game of mathematics is taken from the child's life experience, so the game situation is to be classified according to the clothes worn by the child every day.

Through the games developed in this research, we hope to see children's play behaviors. Does this behavior represent whether the children like the game? Can they learn from the game? This will be described in the following flow theory inquiry.

2.4 “The Flow State” in Early Childhood

A "flow state" is an activity in which the mind is fully engaged. Also known as "being in the zone", it means that the player is in a state of mind during the activity, completely immersed in a feeling of energetic concentration and enjoyment. (Csikszentmihalyi, 1975, 1990 & 1998; Cherry, 2018; Nakamura and Csikszentmihalyi, 2002). In other words, a "flow state" is characterized by a total concentration on what one is doing, thus losing space and time. Nakamura and Csikszentmihalyi (2002) identified six factors that go into experiencing a flow state:

1. Activities we tend to engage in.
2. Focus on the present moment.
3. The Fusion of Action and Consciousness.
4. Loss of reflective self-awareness.
5. The sense of control over the environment and actions - achieving a balance between challenge and skill.
6. Subjective sense of time altered - for example, being able to engage in an activity for an extended period without perceiving the passage of time.

If a game stimulates a child's Flow State, they will spend more time and attention on such a game and will choose it again and again (Csikszentmihalyi, 1975, 1990 & 1998; Cherry, 2018; Nakamura & Csikszentmihalyi, 2002). To compare the level of flow state experienced by children, we collected data on the frequency of their repeated play. Children with higher frequencies of play are considered to have a higher level of flow, while those with lower frequencies of play are considered to have a lower level of flow.

However, people might want to ask, “What can we do to increase children's acquisition ability in a flow state?” The Flow State will occur when a task has clear goals that require specific responses for players to deal with (Csikszentmihalyi, 1975, 1990 & 1998). The “Flow State” can always happen in a well-designed game, which gives players a specific goal and response that allows them to pay attention and be focused on the game.

"Flow state also happens when a person's skills are fully involved in overcoming a challenge that is just about manageable, so it acts as a magnet for learning new skills and increasing challenges." (Csikszentmihalyi, 1998)

"If challenges are too low, one gets back to flow by increasing them. If challenges are too great, one can return to the flow state by learning new skills." (Csikszentmihalyi, 1998)

A well-designed game can provide the player's flow state (Csikszentmihalyi, 1975, 1990 & 1998; Cherry, 2018; Nakamura and Csikszentmihalyi, 2002). In this study, we used the GBL to track the behavior of gamers to see at what age the game stimulated their Flow State. In addition, we applied flow state theory to the game design of the study, presenting developmentally appropriate challenges for children. We observe children's reactions to games and measure their attention levels to

find out their preferences for games (Csikszentmihalyi, 1975, 1990 & 1998; Cherry, 2018; Nakamura & Csikszentmihalyi, 2002).

2.5 Big Data Analysis to Determine Children's Playing Behaviors

Measuring flow state and learning effectiveness is typically done through the use of questionnaires or tests to collect data. However, since young children are unable to complete these questionnaires or tests independently, or conduct interviews, it is necessary to explore alternative methods for gathering data on their behavior and performance.

Data Analyst Doug Laney (2012) defined Big Data as “Big data is high volume, high velocity, and/or high variety information assets that require new forms of processing to enable enhanced decision making, insight discovery, and process optimization” (Bello-Organ et al., 2016). It is what we called the “3V” features of Big Data: Volume, Velocity, and Variety (Rouse, 2016; Laney, 2001; Reips, Ulf-Dietrich, Matzat, Uwe, 2014). This study was dealing with unstructured data, and we analyzed the data according to 3V to find the value and meanings of the data.

2.5.1 Volume

From the development of Big Data till now, the data stored nowadays is not only text-type data (Rouse, 2016; Laney, 2001; Reips, Ulf-Dietrich, Matzat, Uwe, 2014), but also contains data types such as video, music, and images on social media. For more storage size, there is often TB or PB size of storage available in corporations' systems. A children's pad corporation in Taiwan, Kizlab Inc., cooperated with us to provide MS SQL server to collect various data while young children play on the pad so that we can analyze their playing behaviors in this study.

2.5.2 Velocity

In the Age of Big Data, social media can always provide the latest events and news. The old news is often discarded, and people often follow the updated stream. For now, mobile data is quite real-time and the speed of updating data is less than one second. Our research analyzed children's gaming behavior data which Kizpad daily collected all the time so that we can explore their gaming data in the unit of "second" or "millisecond."

2.5.3 Variety

Data can be stored in kinds of file types, such as Database, Excel, Comma-separated Values (CSV), Access, and pure document or text files. To make sense of the data, the data have to be processed and mined/transformed. This study applied a few file types to organize data and make it readable in tables and images to know its meaning immediately.

3 Method

3.1 Materials

For the exploration of children's digital game behavior, the study material is a Math game in a children's learning pad called "Kizpad" (Fig. 2). Kizpad is a pad, especially for young children that size is designed as 22*14 cm, which is child-friendly and that children can operate with their hands; the protective case is rubber/silicone material to protect children from injury. See Fig. 2. Besides, to protect children's eyes, the system's default screen-block time is 10 minutes after using it for 30 minutes, and the screen brightness is adjustable.

The Math game in this study is "Lily's closet," which is mainly about "identification and categorization" belonging to "logic" ability. In the game, users should touch and drag the right clothes shape to the matching closet. Once matched, users will score and the pad will give happy sound feedback. If the match is wrong, a hint will pop up with a warning sound. The game will give star levels after each session according to their gaming performance. The lowest score is one star, and the highest score is three. The game lets children learn through four gradual stages: The first stage is to match color and shape, the second is to train the identification ability, the third is to collate, and finally, the fourth is a sum-up that mixes the previous abilities. See Fig. 3.

Whenever a player enters the game, the system will automatically start recording. The recorded content includes entry time, game duration, game level, star rating (minimum: 1; maximum: 3), user age, and other data. Up to now, the database has collected a total of 81,000 pieces of data.

The key data that we mainly analyze in this study are defined as follows.

Fig. 2. Appearance of Kizpad



Fig. 3. Screenshot of “Lily’s Closet”



1. "Game time" refers to the time from entering to leaving the game. If the user clicks to enter the game multiple times, the game time of each entry is recorded separately.
2. "Frequency" refers to the number of times a user logs in to the game. Every login counts as "Frequency: 1", regardless of playtime.
3. "Learning effect" refers to the user's score at the end of the game. The minimum is 1 star and the maximum is 3 stars. This research hopes that this game can improve children's classification/organization logic ability, and the learning effect will be presented by the number of stars they get.

3.2 Participants and data collecting period

Our research focused on children aged 3-8 in Taiwan. All data was sourced from the cloud database on the backend of Kizpad between 2016 and 2020. With over 200 children's games available, the backend data is very extensive. During these five years, a total of 6,924 children played the game "Lily's Closet," and we collected 53,149 data points. Then we divided into five age groups (see Table 1). To compare play frequency and their learning effects, we selected the top 100 children in each age group for play data frequency and compared the status of all players.

Table 1 shows the total number of users and study participants. See Table 1 for details.

Table 1 Number of participants and Volume of Data

Age Group (Years Old)	3~4	4~5	5~6	6~7	7~8	Total
Number of All Users	1929	1865	1557	1034	539	6924
The volume of All Data	17607	13984	10778	7300	3480	53149
* Number of high-game users	100	100	100	100	100	500
*Volume of data of high-game users	5898	4622	4000	3387	2289	20195

4 Analysis Results

4.1 One-way ANOVA and Post Hoc Test (Scheffe) for Overall Children

We conducted the one-way ANOVA and Post Hoc comparisons by Scheffe to compare the effect of age on different variables in each age condition between 3-8years old in this game. Table 2 and 3 shows our analysis of overall children between 3-8 years old from 2015 to 2020 from the game database.

4.1.1 Analyzing Each Age’s Gaming Frequency

Our analysis result of each age’s gaming frequency for all children is as Table 2.

In Table 2, the age differences in the gaming frequency reach highly significant ($p < .01$). The greatest numbers of players in frequency records are ages 3-4, 4-5, and 5-6 ($N = 1929, 1865, 1557$). The least number of players in frequency records are 7-8 and 6-7 ($N = 539, 1034$). Through research and analysis, we found that: Younger children play this game more frequently than older children.

Besides, the means of each age group show that the ages 3-4, 4-5, and 6-7 have the highest means ($M = 9.13, 7.50, 7.06$; $SD = 14.848, 11.475, 11.211$). The Ages 7-8 and 5-6 have the lowest means ($M = 6.46, 6.92$; $SD = 9.867, 12.138$). We can conclude that: more number of younger children played it than older children, and younger children played it more times than older children on average.

We used Scheffe in the Post Hoc Tests and found significant mean differences in ages 3-4 to all other age groups. Age 3-4 has significantly higher average gaming frequency ($M=9.13$) than Ages 4-5, 5-6, 6-7, and 7-8 ($M= 7.50, 6.92, 7.06, 6.46$), and contrary vice versa. As a result, we can conclude that Ages 3-4 played more times than Ages 7-8 and under. Ages 4-5 and above played fewer times than Ages 3-4 as well.

Table 2 One-way ANOVA and Post Hoc Test (Scheffe) in Each Age’s Gaming Frequency for All Children

Age	Mean	SD	N	F	Post Hoc
3-4	9.13	14.848	1929	9.913**	(3-4) > (4-5, 5-6, 6-7, 7-8) *
4-5	7.50	11.475	1865		(4-5) < (3-4) *
5-6	6.92	12.138	1557		(5-6) < (3-4) *
6-7	7.06	11.211	1034		(6-7) < (3-4) *
7-8	6.46	9.867	539		(7-8) < (3-4) *
Total	7.68	12.537	6924		

*is significant at the .05 level. ** is highly significant at the .01 level.

Table 3 One-way ANOVA and Post Hoc Test (Scheffe) in Each Age's Average Rank for All Children

Age	Mean	SD	N	F	Post Hoc
3-4	1.50	.532	1929	430.456**	(3-4) < (4-5, 5-6, 6-7, 7-8) *
4-5	1.76	.568	1865		(3-4) < (4-5) < (5-6, 6-7, 7-8) *
5-6	2.01	.609	1557		(3-4, 4-5) < (5-6) < (6-7, 7-8) *
6-7	2.27	.622	1034		(6-7) > (3-4, 4-5, 5-6) *
7-8	2.33	.691	539		(7-8) > (3-4, 4-5, 5-6) *
Total	1.86	.655	6924		

*is significant at the .05 level. ** is highly significant at the .01 level.

4.1.2 Analyzing Each Age's Average Rank

For lesser frustration to the challenge, we designed this game as a 3-Stars game for young children. The range of the score is only 1-3: The lowest rank is 1 Star, and the highest rank is 3 Stars. We conducted SPSS 25 to examine differences between groups. Our analysis result of each age's average rank for all children's data is as Table 3.

In Table 3, the age differences in the gaming ranks reach a highly significant ($p < .01$). The means of each age group show that children who achieved the highest average rank are Ages 7-8, 6-7, and 5-6 ($M = 2.33, 2.27, 2.01$; $SD = .691, .622, .609$). The ages 3-4 and 4-5 have the lowest means ($M = 1.50, 1.76$; $SD = .532, .568$). We can conclude that older children achieved a significantly higher rank in this game than younger children.

By Scheffe in the Post Hoc Tests in Table 3, we found multiple pairs are significant as follows: Ages 3-4 have lower average rank ($M = 1.50$) than all other age groups: 4-5, 5-6, 6-7, and 7-8 ($M = 1.76, 2.01, 2.27, 2.33$), and contrary vice versa. Ages 5-6 have a higher average rank ($M = 2.01$) than ages 4-5 ($M = 1.76$), and contrary to vice versa. Ages 6-7 and 7-8 both have higher average rank ($M = 2.27, 2.33$) than 5-6 and under ($M = 2.01$) and contrary to vice versa. As a result, we can conclude that younger children achieved a lower rank than older children: Age 3-4 has a lower average rank than other older children, and so do Age 4-5 and 5-6. Ages 6-7 and 7-8 both have a higher average rank than all other younger children.

4.2 One-way ANOVA and Post Hoc Test (Scheffe) for Highly-gaming Children

For exploring the flow state, we analyzed data of the highly-gaming young players in the game. From each age group, we selected 100 children of the highest gaming frequency in descending order as "highly-gaming" players.

For highly gaming players, we also conducted the one-way ANOVA and Post Hoc Test (Scheffe) to examine the effect of age on different variables in each age conditions between 3-8 years old.

4.2.1 Analyzing Each Age's Gaming frequency for Highly gaming Players

Between 3-8 years old from 2015 to 2020, we selected a total number of 500 highly-gaming players in this game to analyze (Total N = 500). Our analysis result of each age's game time for highly gaming children's data is as Table 4.

In Table 4, the age differences in the gaming frequency reach a highly significant ($p < .01$). The means of each age group shows that the Age 3-4, 4-5, and 5-6 have the highest means ($M = 58.98, 46.21, 40.00$; $SD = 25.730, 17.143, 27.764$). The Ages 7-8, and 6-7 have the lowest means ($M = 22.89, 33.87$; $SD = 13.228, 18.532$). Even for highly gaming players still younger children played much more times than older children in this game. We can conclude that it is significant that: younger children played it more times on average, and older children played it fewer times on average.

By Scheffe of the Post Hoc Tests, we found multiple pairs are significant as follows: Age 3-4 have significantly higher average gaming frequency ($M=58.98$) than all other older age groups and contrary vice versa. Age 4-5 has significantly higher average gaming frequency ($M=46.21$) than Age 6-7 and 7-8 ($M=33.87, 22.89$), and contrary to vice versa. Age 6-7 has significantly higher average gaming frequency ($M=33.87$) than Age 7-8 ($M=22.89$), and contrary to vice versa. Age 7-8 is the group with the least mean frequency ($M=22.89$) among all high gaming players in ages 3-8. As a result, we can conclude that highly gaming players are similar to all player's states, such as Age 3-4 is the highest gaming frequency than all other older ages, and Ages 7-8 play fewest times than all other younger ages. Besides, younger children significantly played more times than older children.

4.2.2 Analyzing Each Age's Average Rank for Highly gaming Players

We presented the analysis result of each age average rank for high gaming players in Table 5.

In Table 5, the age differences of the gaming ranks reach a highly significant ($p < .01$). The means of each age group shows that the Ages 7-8, 6-7, and 5-6 have the highest average rank ($M = 2.55, 2.42, 2.25$; $SD = .386, .430, .380$). The Ages 4-5, and 3-4 have the lowest means ($M = 2.00, 1.62$; $SD = .366, .301$). We can conclude that in highly gaming players, older children scored significantly higher than younger children.

Table 4 One-way ANOVA in Each Age's Gaming frequency for Highly-gaming Players

Age	Mean	SD	N	F	Post Hoc
3-4	58.98	25.730	100	40.553**	(3-4) > (4-5, 5-6, 6-7, 7-8) *
4-5	46.21	17.143	100		(3-4) > (4-5) > (6-7, 7-8) *
5-6	40.00	27.764	100		(3-4) > (5-6) > (6-7) *
6-7	33.87	18.532	100		(3-4, 4-5) > (6-7) > (7-8) *
7-8	22.89	13.228	100		(3-4, 4-5, 5-6, 6-7) > (7-8) *
Total	40.39	24.319	500		

*is significant at the .05 level. ** is highly significant at the .01 level.

Table 5 One-way ANOVA and Post Hoc Test (Scheffe) in Each Age's Average Rank for Highly gaming Players

Age	Mean	SD	N	F	Post Hoc
3-4	1.62	.301	100	96.139**	(3-4) < (4-5, 5-6, 6-7, 7-8) *
4-5	2.00	.366	100		(3-4) < (4-5) < (5-6,6-7,7-8) *
5-6	2.25	.380	100		(3-4, 4-5) < (5-6) < (7-8) *
6-7	2.42	.430	100		(6-7) > (3-4, 4-5) *
7-8	2.55	.386	100		(7-8) > (3-4, 4-5, 5-6) *
Total	2.17	.498	500		

*is significant at the .05 level. ** is highly significant at the .01 level.

We used Scheffe to examine the Post Hoc Tests, and we found multiple pairs are significant as follows: Ages 3-4 have lower average rank ($M=1.62$) than all other age groups, and contrary to vice versa. Ages 5-6 and 6-7 have higher average ranks ($M=2.25, 2.42$) than Ages 3-4 and 4-5 ($M = 1.62, 2.00$), and contrary vice versa. Ages 7-8 have higher average rank ($M= 2.55$) than Ages 3-4, 4-5, and 5-6 ($M = 1.62, 2.00, 2.25$), and contrary vice versa. As a result, we can conclude that, in highly-gaming players, the rank performance is ascending by age significantly: Age 3-4 achieved the lowest rank average than other older children. Ages 5-6 and 6-7 both achieved better rank than ages 4-5 and under; Ages 7-8 achieved better than children ages 5-6 and under.

4.3 Correlation Analysis between Age Group and Frequency

To explore the difference between frequency and age, we used Pearson correlation to compare whether there is a positive and negative correlation and significance between age and frequency. The Pearson correlation test is shown in Table 6.

According to the analysis, the relation between age group and frequency has a significant difference as a negative correlation. Older children played fewer times than younger age.

4.4 Correlation Analysis between Age Group and Gaming Ranks

The ranks set in the game are the same as the learning effects of this game. The higher the ranks present the higher the correct answer and completion ratio during the game. To explore the correlation between age and learning effectiveness, we also used the Pearson correlation to observe the relationship between the two. The analysis is shown in Table 7.

Table 6 Correlation Analysis between Age Group and Frequency

		Age Group	Game Time
Age Group	Pearson Correlation	1	-.314**
	Sig. (2-tailed)		.000

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

Table 7 Correlation Analysis between Age Group and Ranks

		Age Group	Stars
Age Group	Pearson Correlation	1	.375**
	Sig. (2-tailed)		.000

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

According to analysis, the relation between age group and stars has a significant difference as a positive correlation. Older children scored a higher rank star than younger age.

5 Discussion

We would like to explore children's Digital Game-based Learning (DGBL) and their performance in this study. According to the analysis above, we will discuss and answer our study questions as follows:

1. What is the difference between children's gaming behaviors and the learning effect between kids who are highly involved (Highly Gaming Users) in DGBL and kids who are not?

When comparing the ranks of Highly Gaming Users and ordinary players, we found that there is no difference in the results between the two. Older children achieved higher than younger children. Besides, in Tables 3 & 5, the rank of Age 5-6 is significantly lower than Age 7-8 rather than Age 6-7 in Tables 2 & 4. It may mean that highly gaming players in age 5 and above can achieve a higher score. We inferred that highly-gaming children who are older than age 5 can achieve much better scores than younger highly-gaming children. We can conclude that in highly gaming children, older children (age 5 and above) mastered their game skills and knowledge that their achievement is significantly better.

And through Pearson correlation as shown in Tables 6 & 7, we also found that the higher the age, the lower the number of times to play, but their effectiveness is the opposite, the higher the age, the higher the effectiveness. Therefore, this hypothesis is the same as the result of our one-way ANOVA and post hoc analysis. We can assume that the categories of classified games can attract younger children to play, but it does not mean that the more they play the more effective they are. This requires the maturity of children to achieve high learning achievements. In addition, this also explains the definition of the game flow. When the game has a challenge, the player will break through it again and again, but assuming that the player has high achievements in the game, it will reduce the number of times the player wants to play (Csikszentmihalyi, 1975, 1990 & 1998; Cherry, 2018; Nakamura & Csikszentmihalyi, 2002).

According to the analysis, we suggested that playing Lily's Closet repeatedly can be a great practice for young children to improve their identification and categorization abilities. As Piaget (1962) mentioned, young children's cognitive process of constructing knowledge is through constant conflicts of concepts, adjustments, and then acceptance, so that they can form the cognition of the outer world. That is what the so-called assimilation and accommodation process is.

The game rule of scoring in Lily's Closet is to touch and drag the clothes to the appointed closet. Once the wrong match happens, there will be a hint and a red flashlight with a warning sound. Therefore, we consider that if children can repeatedly play DGBL games that improve cognition development, scored or not, the stimulus of the game can still help children to build their cognition right. The analysis data echoes our beliefs in this study.

2. What is the relation between age and gaming frequency?

Younger children significantly played more times than older children. In Table 2, the Post Hoc of all children shows that Ages 3-4 played significantly more times ($M = 9.13$) than any older children. In Table 4, Age 3-4 still has the highest frequency ($M = 58.98$). For highly gaming children, younger groups significantly have higher gaming frequency than older groups, and the gaming frequency is descending by age. We can conclude that younger children love to play it on average more than older children, and this game attracts younger children more than older children.

According to the Pearson Correlation analysis of Table 6, the negative correlation between frequency and age group represents that younger children have a higher motivation than older children. The factors that affect children's repetitive playing could be numerous, such as operating fluency of the game commands, comprehension of the rules, and the challenging degree to them to evoke their motivation. If a game is too easy, children will end up not playing it because it cannot evoke a sense of challenge, though it may attract them first with sound and light effects. Children's mathematical ability is developed by the impact of social culture context, and they absorb the relative information through the living environment and contextual interaction (Piaget, 1962; Vygotsky, 1978). Therefore, we convey that because older children own more life experience than younger children, it is less challenging for them to collate colors and shapes. As they can score three stars easily, the difficulties of the game are not enough for them, so they will not feel interested in it anymore. These are also shown in our analysis data.

3. What is the relation between age and the learning effect?

Because game rank is the score for every round of the educational game, we view "rank" as the assessment of learning from a game. As a result, we interpreted rank as a learning effect in this study.

From the result in Tables 3 and 5, older children significantly have better learning effects in this game. Younger children have a lower rank than older children. In Table 3, we found that children aged 5-6 and under have significantly lower ranks than older groups, and aged 6 and above have significantly higher ranks than those

aged 5-6 and under. We inferred that children older than 6 have mastered the knowledge and skills in this game. This game is about logic and classification. So we can infer that children older than 6 have learned classification logic very well and that they can understand how to score high in this game than younger children.

According to Pearson Correlation finding in Table 7, children's age and their learning effects are significant relations. The analysis shows that the age group and average stars are positive correlations. It means that a game like Lily's Closet which classifies colors, shapes, and patterns, is attractive to children who are 3-4 years old. As they grow older, children's identification and classification abilities develop better, so that their stars and learning effects are higher.

To sum up, our findings are echoing to the Flow State theory (Csikszentmihalyi, 1975, 1990 & 1998; Cherry, 2018; Nakamura & Csikszentmihalyi, 2002): if the challenge is too easy for players, they will lose interest in it; contrary, if the challenge is just manageable, the players will stick to it and play it repeatedly, and that is where the flow state happens. The fact that older children (age > 6) played less than younger children shows that the game content about basic classification is too easy for older children. The other fact that the game most attracts Ages 3-4 in general, shows that this game is designed well and the content is just manageable especially for ages 3-4, so they want to challenge it multiple times.

6 Implication: Applying in Teaching and Game Design

Therefore, from the above results and discussion, our findings are as follows:

1. The Mathematics classification game is appropriate for ages 3-4. A game of sorting clothes in the closet can attract children aged 3's attention.
2. Games about classification are appropriate for age 3. They love to put things in order and are most willing to play this type of game repeatedly, which can also stimulate them with a sense of order.
3. We find age differences in children's preferences for games. On game performance in these games, the higher the age, the higher the achievement. But for game times, it is the opposite: the younger the age, the higher the game times. Younger children were willing to play an average of more times although they did not achieve high ranks. Younger children at ages 3-5 may not clearly understand what is happening in this game and do not get high scores, but they are attracted by it so they are willing to repeat it because the tasks are challenging enough. That means they are in the flow state in this game. In flow state theory, Csikszentmihalyi (1998) indicated that flow state happens when a person's skills are fully involved in overcoming a challenge that is just about manageable, so it acts as a magnet for learning new skills and increasing challenges. In this game, the challenge is about classification skills that players need to arrange Lily's clothes in order. The challenges are just appropriate for young children especially aged 3-5, so they can repeat play it until they master those tasks.

As a result, on curriculum and game design for young children ages 3-5, we suggest as follows:

1. Teachers and game designers can use the 3-4-year-old children's perspectives on the classification to design more digital and physical games with relevant backgrounds.
2. Preschool teachers can group children across ages that let older children guide young children to play this type of game. If older children can lead younger ones to play the game, we may lower young children's frustration with rankings, and increase older children's confidence and cooperation ability.
3. We suggest teachers create a learning corner of games to let different ages cooperate and pass the challenges. Teachers can also extend the game in the classroom to teach. For example, to decorate different classrooms as rooms in the game for all children to join. In this way, children who do not like mobile games can also have a learning chance, and for children who love this game, this setting can evoke their learning motivation to learn more other knowledge.
4. We suggest parents apply educational mobile games in at-home learning. While schools are closed during a pandemic or other situations, a mobile device can be a useful and easy tool to evoke children's autonomous learning at home. Choosing a well-designed game and setting limited playtime can be helpful to allow children to learn with joy.

For the suggestions for this type of mathematical classification game for young children, we have the following suggestions:

1. Set a timer for children playing this type of game and notice whether they are overwhelmed by this game. We have provided the average gaming frequency for each age in Tables 2 and 4. Teachers and parents can take our average frequency as the index to understand their children as normal children or highly-gaming children.
2. If teachers and parents found children ages 3-4 interested in this game but with poor rank, we suggest helping them with a hand to give some hints and scaffoldings. This will let them have confidence and lower their addiction to this game.
3. If the children are highly gaming players in this type of classification game with great rank stably, we suggest:
 - Giving them advanced training in mathematical logic. It may represent that they are talented in math, logic, and geometry. Once they find another similar challenge but harder, they may shift their attention from addicting to this game.
 - Using similar elements in life environments to expand their interests to other learning materials.
 - Praising their performance in the game that they are good at tidying up clothes. In this way, they can have confidence in organizing their own life and stuff.

- Decorating a classroom or learning corner to teach children the knowledge in this game. In this way, teachers can bring virtual teaching material to life, and a stimulus to a child's learning motivation.

7 Conclusion and Future Study

This study explores the data behind the digital game, “Lily’s Closet.” This game is to improve children’s identification and classification ability it let them colate the clothes by the same colors and types. We data-mined the database of this game to analyze children’s gaming behaviors in digital games. Our study results that older children have a higher learning effect but a lower frequency. We infer that it is because older children are interested in higher-difficulty games.

As a result, this study suggests that children can learn through digital games if they want to cultivate their identification and classification ability. Children can acquire knowledge in this type of game when repeating to play it. Besides, we find that, for younger kids, we can provide simpler games for them to practice constantly; for older children, we should provide multiple types of choices for them to discover interests from learning in the games.

In the future, we look forward to having more different games and viewing children’s behaviors in games with different data perspectives, helping teachers, parents, and game designers to better understand children’s needs and learning representations under games.

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Data Availability The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Conflict of interest We have no conflict of interest to disclose.

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