Research on the Number Construction Ability of Senior Kindergarten Children under Observational Learning

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Abstract

This research studied whether observational learning, arising from task-related tools, has a positive impact on the number construction ability within 10 for senior children in preschool. The study also compared this with the effects of traditional teaching methods. The participants were 53 senior children from kindergarten. They were randomly divided into four control conditions: folding arms, circling, constructing, and observational constructing. Children were provided with three color strips of different lengths before the test. The shortest represented the number 1, the medium length represented the number 2, and the longest represented the number 5. Each child received the same demonstration teaching, with instructions to construct numbers using the fewest color strips. The experimental results confirmed the hypothesis: performance under the observational constructing condition was higher than under the folding arms and circling conditions. When children observed their peers' actions and the rewards and punishments given by the experimenter in a new teaching environment, their observational learning positively affected their number construction ability. At the same time, observational learning based on role model performance and teacher feedback made children more active in learning.

Keywords

Preschool education, Senior children, Observational learning, Number construction.

1. Introduction

1.1. Overview of Preschool Education

Preschool education is a systematic, planned, and scientific form of education, where parents and kindergarten teachers utilize various methods and materials to stimulate children's brains. This stimulation gradually perfects the functions of different parts of the brain.

Preschool education is one of the crucial components of pre-primary pedagogy and is a part of the scientific system that constitutes pre-primary pedagogy. Childhood stage is the foundational phase of cognitive development and is also the period of fastest growth. Proper and accurate preschool education plays a significant role in the intellectual development of children and their future growth[1]. Preschool education is the beginning of lifelong learning, an essential part of the national education system, and a vital public welfare undertaking. Thus, the education of preschool children is foundational, bearing profound implications for their future development[2]. The experiments primarily focus on the preschool stage, aiming to provide constructive suggestions for improving the number construction abilities of preschool children.

1.2. Research Status Abroad

Yu and Wang from the College of Educational Science at Northeast Normal University have interpreted the specific content of preschool education theory in China from a macro perspective. They advocate for a scientific development perspective, emphasize balanced development, propose appropriately increasing the investment in preschool education funds, as well as fully utilize and expand preschool education resources. This is deemed the essential path for China's leapfrog development in preschool education[3]. In contrast, Yang from the College of Educational Science at South China Normal University in her work "Children's Early Development and Issues of Movement and Exercise in Education - Four Discussions on Evolution, Development, and Early Childhood Education," as well as Wangying Zhang and Shifeng Zhang from the College of Education at Hebei University in their article "Theoretical and Practical Aspects of Outdoor Play for Children in the UK" focus on a micro perspective. They delve into the details of the content of children's education within the theory of preschool education in China. They believe that the early movement development of children is not only an essential indicator of their cognitive development but also a universal characteristic of development[4]. Apart from studies on the modes and methods of how subjects interact with objects, there are also articles on the objects themselves within the preschool education theory. For instance, Zhang and Li from the College of Education at Southwest University discussed what the subject of study in pre-primary pedagogy should be, aiming to answer the question of what pre-primary pedagogy studies[5]. The definition of the research subject in pre-primary pedagogy experienced a transition from "law-based theories" to "phenomenon-based theories", and then to "theories combining phenomena and laws", finally culminating in "comprehensive theories"[6].

According to the "Overview of Chinese Core Journals" published by Nanjing University (2008 edition), there are five journals classified as core journals[7]. This indicates that the current research has attracted attention from high-quality magazines. However, considering the publication of 158 articles over the past decade, there is still a limited number of documents, and not many core journals cover the topic, suggesting that there is ample room for expansion in this research[8]. On the other hand, highly cited literature mainly elaborates on the theoretical foundation of preschool education from an educational perspective, focusing on real-world problems for research orientation. There is a lack of theoretical support from various disciplines such as sociology, management, and economics. This shows that the breadth and depth of research in the field of preschool education need further strengthening[9].

1.3. Domestic Research Status

The history of China preschool education is an essential component of the construction of the pre-primary pedagogy discipline and is one of the vital resources for the development of preschool education theory[10]. The history of preschool education not only contains records of historical events related to preschool education but also involves understanding and narrating these events. This makes the history of preschool education an intellectual history and contemporary history that is continually rewritten by researchers. Researching the history of preschool education is undoubtedly a creative endeavor[11]. It not only helps us deeply understand the past but also aids in profoundly explaining the present and anticipating the future. It assists in recognizing and understanding the objective laws of preschool education development, ensuring a better grasp of the timing of its progression[12]. Jiang, in his article "Three Understandings of the History of Preschool Education and Their Academic Value," recognizes the academic value and practical significance of preschool education history from three perspectives: it is contemporary history, it needs continuous writing, and it is creative research[13]. Zhu, in his article "A Retrospective and Outlook on a Century of Research in China's Preschool Education History," believes that a century of research on China's preschool education history can be divided into three phases. As an emerging discipline, the study of the history of preschool education in China has achieved significant results, such as the emerging consciousness of the discipline, relatively mature general history research, preliminary expansion of research by eras, and an increasing richness in personalities studied. However, there are still many areas to be explored, such as conducting meta-research on the history of preschool education in China, deepening era-specific research, and urgently expanding topical research[13].

Preschool education is the education of the nation and for everyone. The study of preschool education theory is not merely the concern of scholars or practitioners alone[14]. Therefore, to develop preschool education effectively in the future, three functions should be fully utilized: Firstly, fully leverage the role of the state to ensure the perfection of policies and systems, which is the foundation and essence of its development. Secondly, fully harness societal supervision and the role of public opinion to ensure the implementation of policies and the establishment of a complete system. Lastly, individuals should actively play their part. Scholars can engage in theoretical research, while frontline workers can identify existing problems from their work experiences[15]. These three functions complement each other and are indispensable. Only with good coordination can we ensure the resolution of various issues in the current preschool education theory in our country and continually develop in a positive and healthy direction.

1.4. Research Status of Observational Learning

This study focuses on how observational learning promotes children's number construction abilities. Observation can aid in understanding and facilitate learning. Bandura's theory of observational learning emerged in the 1960s. Observational learning is a process where an individual, by observing the actions of another person (or a role model) (actions that are new to the observer) acquires a symbolic representation of the demonstrated behavior, which then guides the learner to perform corresponding actions[16]. Observational learning, also referred to as vicarious learning, places significant emphasis on the critical role that role model demonstrations and the social environment play in shaping and developing individual behaviors. Observational learning is divided into four processes: attention, retention, reproduction, and motivation. Each process contains a wealth of educational information resources[17]. Based on Bandura's theory of observational learning, this research delves deep into the positive effects of children's observational learning behaviors on their number construction abilities.

Observational learning holds a very significant position in human learning. For a long time, observational learning has been considered an effective means of transmitting values, attitudes, thoughts, and behavioral models[18]. Observational learning is one of the essential ways humans learn. In social life, people acquire new behavioral information from others through observation, imitate what others do, and are influenced by others' behaviors. Observational learning is an essential means, especially for children, to adapt to society or a vital mode of socialization[19]. Therefore, to effectively guide children's observational learning and improve education and teaching, it's necessary to understand Bandura's theory of observational learning[20]. As a fundamental learning method, observational learning offers a convenient route for children's learning. Currently, domestic research on children's observational learning mainly focuses on two aspects: first, the theoretical research on the application value of observational learning; second, the research on the influence of observational learning on certain behaviors or objects. Research on the impact of observational learning on children's number construction abilities is relatively rare, and studies using experimental methods are also few. Therefore, this study attempts to employ experimental methods to explore the influence of observational learning on children's number construction abilities, aiming to provide a scientific basis for improving children's number construction capabilities.

When research shows that observation and construction each have a positive impact on learning math, it becomes crucial to explore the effects of combining these two elements on the math learning process. Although some studies in the fields of math and constructivism have examined the role of model construction in math learning[21], in our eyes, no research has ever investigated the effects of senior children in preschool education using colored sticks and paired colored stick tools for number construction and observational learning. Through teachers demonstrating how to use colored sticks for number construction, children, through observational learning, begin to independently construct numbers using the colored sticks and tools, integrating observational learning with active construction. According to the findings of Dearborn and Ross (2006), a complex environment makes learning more challenging, but it also enhances the long-term effects of learning and strengthens subsequent performance[22].

Considering these results, it can be believed that the beneficial effects of observational learning can be transferred to situations of observational construction. Moreover, people might think that the combination of doing and observational construction could lead to a rich multi-sensory cognitive model[23], which not only contains somatic sensations but also visual content[24]. On the other hand, it can also be believed that when observation and number construction are combined, the complexity of the task increases to a certain extent, which might hinder the learning process. In this research, we explore this issue by comparing the observational construction based on matching colored stripe Teaching Aids with self-construction without colored stripe Teaching Aids in learning situations of numbers within 10.

The focus of this study is on the positive role of observational learning in children's learning processes, mainly manifested as the study of the impact of observational learning, resulting from tools related to the task, on the ability of senior children in preschool education to form numbers within 10 using number construction. The results of the study show that observational learning, resulting from Teaching Aids related to the task (specifically colored stripes), enables children to more accurately and quickly construct numbers within 10. This means that the children's test performance under observational construction conditions is higher than under the conditions of folding arms and circling selections. In addition, we also explored whether the extent to which parents value their children's math education would have different effects on children's understanding and application level of new tool concepts and test rules. Therefore, we added two questions in both the parent and child questionnaires: one asking parents to self-evaluate how much they value their child's math education and another asking children how often they think their parents guide them in math learning.

2. Participants and Research Methods

2.1. Participants

In April 2018, senior children from three kindergartens in Nanjing were selected for the study. There were 53 normal children in total, with 28 boys and 25 girls. Taking each child as an individual unit, 53 parent and child questionnaires were distributed during the experiment. All 53 child questionnaires were effectively retrieved, resulting in a 100% effective questionnaire rate. Similarly, all 53 parent questionnaires were effectively retrieved, also resulting in a 100% effective questionnaire rate. The average age of the normal children was 5.60 years old.

Table 1. Basic Statistics of the Participants

Group	Age	Male	Female	Total
Normal children	5	11	10	21
	6	17	15	32
	Total	28	25	53

2.2. Tools

2.2.1. Questionnaires

Self-compiled parent and child questionnaires were both formulated using a five-point Likert scale. The parent questionnaire consisted of 17 questions, mainly divided into 4 categories: child's performance, parent's attitude, parent's behavior, and parent's expectations. The child questionnaire had 5 questions, primarily focusing on the children's level of liking for the test and tools, their perception of the test's difficulty, whether they believed they understood the exercises correctly, their fondness for mathematics, and their self-assessment of the frequency of parental guidance in math. These questions were measured using a five-point scale. After obtaining consent from the students, schools, and parents, the questionnaires were administered individually. Experimenters distributed the questionnaires and provided guidance on filling them out. The questionnaires were collected on the spot and checked for completeness. In the experiment, 53 questionnaires each were distributed to parents and children. All 53 child questionnaires were effectively retrieved, resulting in a 100% effective questionnaire rate. Similarly, all 53 parent questionnaires were effectively retrieved, also resulting in a 100% effective questionnaire rate.

2.2.2. Teaching Aids

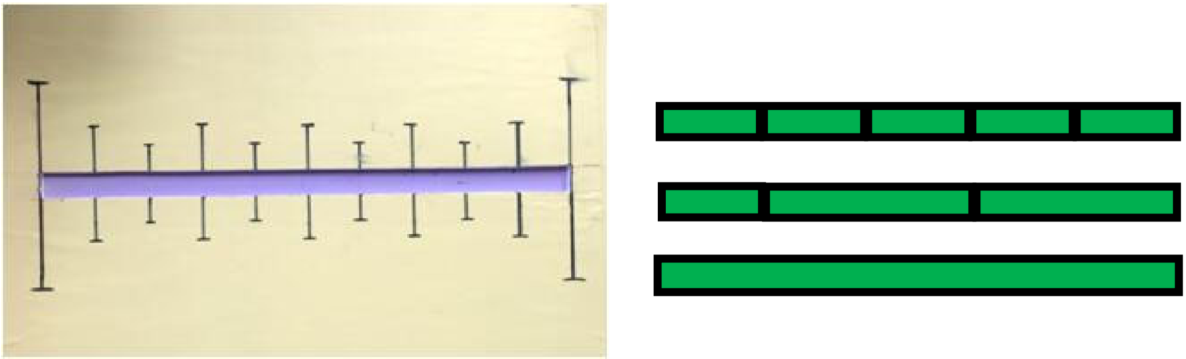


Figure 1. Illustration of the Teaching Aids

Note: Although each child's mathematical ability varies, there are some guiding standards for what senior children should grasp in mathematics. By the time they graduate from kindergarten, children should be able to recognize numbers within 10 and should be capable of calculating numbers within 10 using 1, 2, and 5.

2.2.3. Statistical Methods

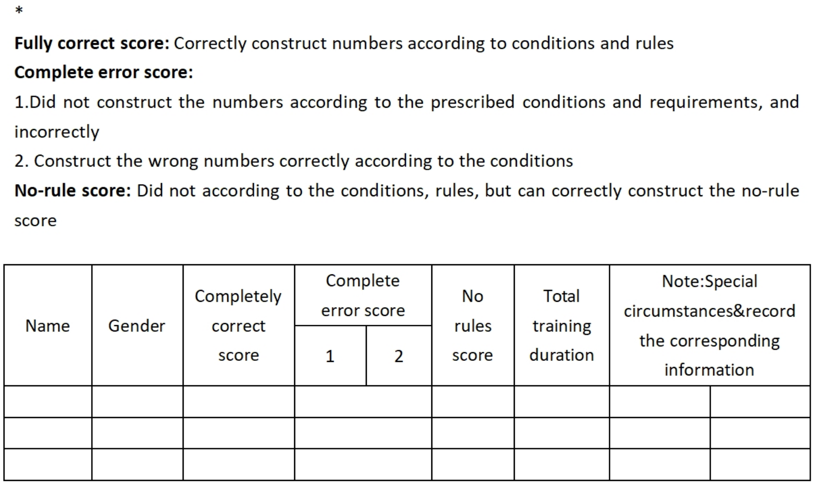
SPSS 19.0 statistical software was used for analysis. Data from the children's experiments were described using mean (M), standard deviation (SD), variance (F), significance (P), and eta-squared (η^2) to analyze and discuss the relationship between observational learning and number construction ability. The parent questionnaire data were subjected to reliability analysis, with a reliability coefficient of 0.9 and a split-half reliability of 0.86. Eta-squared (η^2) was used as the determinant indicator for estimating the size of the effect: η^2=0.01 corresponds to a small effect, η^2=0.061 to a medium effect, and η^2=0.14 to a large effect. Table 2 displays the performance of four different types of experiments during the testing phase. In addition, we also studied the correlation between age and gender.

3. Procedure

Among the children participating in the experiment, 53 were senior normal children from kindergartens. On a regular school day, the children were tested individually in a distraction-free classroom. This study had four conditions: folding arms, circling, construction, and observational construction. All children were randomly assigned to different conditions, and every child practiced constructing numbers within 10 using 1, 2, and 5. After the training phase, all children took three final math tests, where their mathematical construction skills with numbers within 10 were assessed. For the randomization process, the experimenters used the seating chart provided by the teachers to assign all children to different experimental conditions. The size of this group depended on the total number of children participating in the experiment. For instance, if 20 children participated in the experiment, each condition contained 5 children.

Two experimenters informed the experimental children that each child would do some math exercises and tests with the experimenter in a distraction-free classroom. Inside the classroom, the experimenter recorded each child's name and gender on the experimental record form. Then, a detailed explanation was given individually to the child on constructing numbers within 10 from smaller units, emphasizing that three differently sized colored stripes represented 1, 2, and 5, respectively. Additionally, the experimenter emphasized the basic rule: children must use the fewest number of stripes to construct numbers within 10. After a standardized explanation, the experimenter demonstrated the construction twice, specifically for the numbers 8 and 3 (for example, for 3, one should use one stripe representing 1 and another representing 2, instead of choosing three stripes that represent 1). After the experimenter's demonstration, each child performed two independent constructions of the numbers 8 and 3. Those who could correctly construct numbers according to the rules proceeded to the test. Since not all children were familiar with this rule concept, special attention was given to those who couldn't construct correctly. The experimenter would explain and correct their mistakes before proceeding to the math construction test.

In the math construction test for the "folding arms" condition group, the experimental children first randomly drew a card with a number within 10 from the table and loudly announced the number they drew. To prevent the children from directly touching the colored stripes, they were instructed to sit at the desk with their arms folded. Therefore, all experimental children used a verbal approach, loudly stating the smaller units (1, 2, 5) that composed the number within 10. The experimental children were tested three times, and the experimenter recorded their scores as either entirely correct, entirely wrong, or without following the rule. (Refer to the recording form in Figure 2.)



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Fully correct score: Correctly construct numbers according to conditions and rules

Complete error score:

1.Did not construct the numbers according to the prescribed conditions and requirements, and incorrectly

2. Construct the wrong numbers correctly according to the conditions

No-rule score: Did not according to the conditions, rules, but can correctly construct the no-rule score

Name	Gender	Completely correct score	Complete error score		No rules score	Total training duration	Note:Special circumstances&record the corresponding information	
			1	2				

Figure 2. Participant Score Recording Form

In the math construction test for the "circling" condition group, the experimental children sat at a desk with an A4 paper printed with a black number line (Refer to Figure 3) and a pencil. The experimenter gave a brief explanation of how to use the number line and pencil, after which the children randomly drew a card with a number within 10 from the table and loudly announced the number they drew. The children then directly circled the position of that number on the number line with the pencil. The experimental children were tested three times, and the experimenter recorded their scores as either entirely correct, entirely wrong, or without following the rule.

Figure 3. Black Number Line Illustration

In the "construction" condition group's math construction test, the experimental children sat at a desk with three sets of colored stripes. The children began by randomly drawing a card with a number within 10 from the table and loudly announcing the number they drew. They then constructed the said number by arranging the colored stripes. The children underwent three tests, with the experimenter recording scores for being entirely correct, entirely wrong, or without following the rule.

In the "observational construction" condition group's math construction test, the experimental children sat at a desk equipped with a set of colored stripe Teaching Aids and three sets of colored stripes. The experimenter provided a brief explanation of how to use the colored stripe teaching tool in conjunction with the stripes. (The center of the colored stripe teaching tool has a scaled groove that can accommodate 10 stripes representing the number 1.) The children then randomly drew a card with a number within 10 from the table and loudly announced the number. With the observation of the colored stripe teaching tool and referring to the tool's scale, the children constructed the number by placing the least number of colored stripes inside the teaching tool.

After three tests, the children were not provided feedback about their test results. Subsequently, the experimenter administered a child questionnaire to the experimental children, which was designed based on a five-point Likert scale. The questionnaire contained 7 questions; the first two were mock questions to familiarize the children with the option meanings, while the remaining five were formal questions relevant to the experiment that required recording the choices. The test was then concluded.

4. Results

4.1. Analysis of Participant Test Results

Before the formal testing, participants were randomly assigned to four different types of experimental groups. We then analyzed and compared the test performance of these four groups. The test performance was reflected through four different scoring standards: full correct score, full incorrect score 1, full incorrect score 2, and rule-less score. Variance analysis of different groups and experiment types yielded the following data representation: For children with full correct scores: F(1,78，4.625)，P=0.035，η2=0.057. For children with full incorrect score 1: F(1,78，3.019)，P=0.86，η2=0.038. For children with full incorrect score 2: F(1,78，1.521)，P=0.221，η2=0.019. For children with rule-less scores: F(1,78，0.899)，P=0.346，η2=0.012. Therefore, it is evident that the variance was the largest in the full correct scores, where $0.01<P=0.035<0.05$, making the result quite significant. In the case where children constructed numbers correctly but did not follow conditions and rules, the variance was the smallest with $P=0.346>0.05$, making the result not significant. In the number construction test for senior children in preschool, children's test scores based on the mean (M) values were: circling M=2.38; observational construction M=1.64; folding arms M=1.62; and construction M=1.38.

Table 2. Analysis of Experimental Situations

Group	Number	Category		Correctly Constructed Numbers (Conditions Met)	Incorrectly Constructed Numbers (Conditions Not Met)	Correct Conditions, Incorrect Numbers	Incorrect Conditions, Correct Numbers
Normal Children	13	Folding arms	M	1.62	.85	.15	.38
			SD	1.121	1.144	.376	.650
	13	Circling	M	2.38	.31	.08	.23
			SD	.961	.855	.277	.599
	13	Constructing	M	1.38	.31	.00	1.31
			SD	1.193	.630	.000	1.251
	14	Observational Constructing	M	1.64	.07	.00	1.29
			SD	1.151	.267	.000	1.069
	53	Total	M	1.75	.38	.06	.81
			SD	1.142	.814	.233	1.039
		F		4.625	3.019	1.521	.899
		P		.035	.086	.221	.346

4.2. Analysis of Parent's Questionnaires

To understand whether the aforementioned results were related to other factors, such as children's performance, parents' attitudes, parents' behavior, and parents' expectations, we distributed questionnaires to the parents to gather insights. In the minds of parents of senior preschool children, the metrics are as follows: Children's performance in math learning: M=17.679, SD=3.730. Parents' attitude towards their child's math learning: M=25.604, SD=4.226. Parents' behavior towards their child's math learning: M=16.264, SD=3.253. Parents' expectations for their child's math learning: M=8.359, SD=1.618.

Table 3. Parent’s Questionnaire Analysis Report

Group		Children's Performance	Parent's Attitude	Parent's Behavior	Parent's Expectations
Normal Children	M	17.679	25.604	16.264	8.359
	SD	3.730	4.226	3.253	1.618

4.3. Analysis of Children's Questionnaires

After the three tests, we conducted a questionnaire survey for all children. Among the senior children in preschool, the metrics are as follows: Liking level for the test and Teaching Aids: M=4.72, SD=0.755. Level of understanding the teaching: M=3.94, SD=1.216. Perception of test difficulty: M=4.57, SD=0.888. Fondness for mathematics: M=4.62, SD=0.686. Perceived number of times parents tutor: M=3.94, SD=1.512.

Table 4. Children's Questionnaire Analysis Report

Group		Do you like this game?	Do you understand this game?	Do you find this game difficult?	Do you like math?	Has your family taught you math before?
Normal Children	M	4.72	3.94	4.57	4.62	3.94
	SD	.455	1.216	.888	.686	1.512

5. Discussion

Based on the experimental process records, we observed that all children, when exposed to a new teaching environment and new teachers, exhibit significant interest. Children show a strong desire to perform during the math test, eliciting the Hawthorne Effect. The Hawthorne Effect refers to the situation where effort or performance increases due to receiving additional attention[24]. The one-on-one guidance and affirmation from the experimenter during the test motivated the normal children to complete the number construction quickly and accurately.

Among the senior children in preschool, children under the circling condition performed best in the test. This is inconsistent with the positive impact of observational learning on number construction. The primary reason for this phenomenon might be: under the circling condition, when children see a number, they silently count to the position of the drawn number on the number line and then circle it, rather than directly circling the position of the number. This could mislead the experimenter when recording scores.

When senior children constructed numbers within 10 during the testing practice phase, there was no significant difference in test performance between the construction group and the observational construction group. We speculate that this might be because the normal children selected for the experiment were from the older preschool age group. These children have well-developed cognitive and numerical abilities, making the colored stripe Teaching Aids somewhat redundant for them, without any active facilitation. A potential explanation for this result is that all children experienced additional (and ineffective) cognitive load due to being required to engage in both observational learning and number construction simultaneously. A similar rationale can also account for the null findings in this study. Given the dual task of both constructing and observing their construction behavior, they might not have had adequate memory capacity left for learning[25]. Extensive dual-task paradigm research, which examines scenarios where two tasks are performed simultaneously, indicates that our ability to perform tasks in parallel is limited[26]. When the demands of two tasks (e.g., perception and motor operations) exceed an individual's processing resources, a performance decline is anticipated, often referred to as the dual-task cost[27]. What might be mentally taxing and thus creating additional load is requiring the children to observe the experimenter's actions and simultaneously combine it with their observational use of the colored stripes and Teaching Aids. Seeking to garner the child's intrinsic performance by creating this combination of observation and construction makes it challenging for the child to simultaneously apply the number construction ability acquired through observational learning[28].

Based on the analysis of the children's questionnaire results, it is found that most senior children perceived the overall experimental process as relatively simple. The filling out of the five-point scale is predicated on the idea that individuals can introspect on their emotional and cognitive processes and report the mental effort they invested to meet the demands of a task. While a fair amount of research suggests that adults are capable of doing this, it's plausible that children might encounter difficulties when using these introspective self-report scales. Some studies have found that children tend to respond in extreme ways (e.g., always opting for the endpoints when asked to use similar types of rating scales). For instance, one study demonstrated that among children aged 5 to 12, they are more likely to respond in extremes when assessing subjective states (as opposed to physical states), either really liking or not liking at all, whereas older children have a greater ability to use middle gradations of the scale (e.g., liking a little bit)[29].

While this explanation can account for why there's an exaggerated tendency at both ends of a response continuum, it doesn't elucidate why the majority of children endorsed positive selections. Another interpretation of the current result pattern is the social desirability bias; people generally tend to answer questions in a way they think will be viewed favorably by others. Even though no feedback was given regarding the children's test performance throughout the experiment, it's possible that the children desired to gain the experimenter's approval by opting for what they perceived as the most favorable choice. In this case, the favorable choice is full comprehension and great liking, without any perceived effort or difficulty (e.g., children might opt for answers that make them appear more intelligent). Future research should mitigate such social desirability biases, perhaps by explicitly instructing the children that high scores on the effort scale are just as good as low scores.

In addition to the general remarks by parents on children's mathematical learning abilities and introspective capabilities, there are other more specific factors that might have contributed to the current results.

Although there is a lack of dedicated studies to concepts such as effort or workload, we pointed out in our research that children tend to conflate concepts when faced with perceived difficulty. For instance, several children, after completing a numeric exercise, directly anticipated the upcoming mental effort question by stating "very easy" instead of "not at all effortful" (i.e., on a 5-point Likert scale). Therefore, we can hypothesize that the distinction between the two concepts might not be clear for children. Future research would benefit from more performance-based measures of mental effort. In performance-based techniques, cognitive load is implicitly assessed by providing children with a concurrent secondary task alongside the primary task. In this procedure, the performance on the secondary task should reflect the level of cognitive load imposed by the primary task. Typically, secondary tasks encompass simple activities like remembering a string of letters or words, or tasks that require sustained attention, such as detecting a visual or auditory signal. For sustained attention tasks, typical performance variables are reaction times, accuracy, and error rates, while for memory tasks, it's the number of words remembered.

6. Recommendations

This study seeks a method to incorporate observational learning into the classroom math curriculum. This not only allows children to use tangible teaching aids to replace traditional, dull numbers and algebra but also has a positive guiding effect on the children's understanding of digital concepts. Children can find the connection between the provided teaching aids or some tangible items and abstract mathematical symbols through observational learning and hands-on construction. The results show that for senior children in pre-primary education, colored sticks and related Teaching Aids did not elicit a significant effect on observational learning. Moreover, differences in children's interest, perceptual difficulties, understanding, and psychological efforts cannot explain this impact.

There are no differences in conditions among the variables of children's interest, perceptual difficulties, understanding, and psychological effort. Although conclusions from a single study must be approached with caution in terms of educational practices, the current findings are of significant insight for the educational field. By simply adding observational learning to traditional math exercises, math performance can be improved compared to primary sitting postures and writing methods. From a practical standpoint, these results are promising, as observational learning can be easily integrated into traditional number construction practices without the need to purchase expensive new teaching methods and materials. Due to this simple application and low-cost teaching approach, teachers are more likely to incorporate observational learning into their classrooms, setting examples. Furthermore, observational learning based on exemplary performance and teacher feedback can also make children more active and autonomous in learning.

7. Limitations and Future Research Directions

This study has some notable limitations. Firstly, this research did not include a pre-test. A well-known drawback of pre-testing is that it might confound the math training since participants become prepared for the test items. As this experiment employed new teaching methods and tools, each child was tested directly after receiving the same instruction from the experimenter. If pre-testing was conducted, the familiarity of the children with the testing process could affect the purity of the formal math construction test results. Additionally, with numbers less than 10, conducting a pre-test could easily result in a situation where children encounter repeated testing during the official test. Therefore, we couldn't directly assess the math construction level of senior children before the unified instruction phase by the experimenter and couldn't determine the specific training outcomes of different types of experimental groups. However, since participating children were randomly assigned to one of the four experimental groups, we can anticipate that prior number construction skills would be similarly distributed across different testing conditions. To avoid this priming effect, we chose a post-test design. Secondly, based on the experimental design, we couldn't conclude how specific elements of observational learning promoted numerical construction skills during the training and testing stages. Under controlled conditions by forcing children not to use their hands and not to touch the colored strips to assist in number construction, their performance might be more challenging compared to the construction and observational construction experimental groups, because they couldn't use their hands as memory and positioning devices, nor could they use the colored strips for concrete imagery thinking. Future research should separate these individual elements and integrate them into a single control group, allowing all children in the experimental groups to use their hands for math construction and incorporate elements of autonomous construction.

Another topic for future research is to study the impact of children observing each other's learning and the experimenter's immediate feedback on the performance of the demonstrating child on children's numerical construction ability (before the formal test, they are given three blue tokens as a base score of three points. If they operate correctly, the experimenter awards one red token; if they operate incorrectly, one blue token is deducted. At the end of the test, children can exchange prizes with the red tokens they hold). For instance, we can select a child to demonstrate from each randomly assigned experimental group for one-on-one instruction and testing. Feedback will be provided on their test results, allowing other children from the same experimental group to observe both the demonstrating child's operations during the test and the teacher's feedback. This will substantiate that, in a new teaching environment, children's observational learning - observing their peers' behaviors and the experimenter's rewards or penalties - can have a positive effect on their own numerical construction abilities. This research direction is an extension of the current experimental topic. The above experiment is just a prototype. Specific details will be refined and further researched in the future.

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