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Whole Brain Teaching and Multi-Sensory Environments on Cognitive Science Development: Moderated by Children's Learning Preferences

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ABSTRACT

Objective: This study aims to determine the impact of whole-brain learning and a multi-sensory environment on developing cognitive abilities in early childhood. **Method:** This research method uses a quantitative, quasi-experimental approach. The State University of Malang Laboratory Kindergarten's classes B and C served as the population for this study. The sample was determined by purposive sampling, so there were 60 children. We carried out the data collection process in this study using observation and closed interviews. We conducted observations to evaluate children's cognitive science abilities, encompassing information processing, intelligence, reasoning, language development, and memory. We used closed-ended interviews to measure the children's visual, audio, and kinesthetic learning styles. We processed the data using the SPSS 17.0 program, which included a validity test to determine the product moment, a reliability test with alpha Cronbach, a normality test with Kolmogorov-Smirnov, a homogeneity test with the Levene test, and hypothesis testing to test a two-way ANOVA. **Results** show a positive relationship between cognitive science development and learning preferences in children's learning styles, whether visual, audio, or kinesthetic. **Novelty: This** research can improve children's effective recall of information and open opportunities for more inclusive and adaptive learning according to each child's cognitive needs. Therefore, further research in this area has the potential to shape educational practices that are more effective in recognizing the development of cognitive science in children's learning.

INTRODUCTION

Multi-sensory environments are essential in child development, including early childhood education. Multi-sensory environments play an important role in early childhood education programs, such as the holistic approach to learning and development. Sensory integration, through the application of sensory activities and stimuli, has been shown to improve the well-being of toddlers in the everyday preschool classroom (Vorkapić & Osojnak, 2022). Research has also shown that early childhood educators recognize the importance of sensory needs, especially for children with autism spectrum disorders, and incorporate evidence-based sensory-related strategies in their classrooms (Zabeli & Gjelaj, 2020).

Education professionals have utilized multi-sensory environments to tackle dementia-related behaviors, demonstrating positive outcomes in enhancing the classroom environment and performance of students with autism or dyspraxia (Cameron et al., 2020). Common issues with multi-sensory environments in early childhood education programs include a comprehensive understanding of how these environments engage young learners and their potential impact on their development (Ahmad & Khasawneh, 2024; Kucirkova, 2024). Specifically, the challenge lies in the effectiveness of multi-sensory environments in promoting holistic development, Cognitive, social, and emotional skills are included in early childhood education (Oyewole et al., 2024; Zhou, 2024). Failure to resolve this issue could limit children's sensory experiences, impeding their overall development and learning outcomes. People recognize the importance of multi-sensory environments in enhancing children's responsiveness, particularly in early education (DeBoth et al., 2022; Finnigan, 2024).

Whole-brain teaching emerges as a pedagogical approach to foster children's cognitive abilities by explicitly enhancing concentration, rapid and accurate thinking, and adept execution of instructions. Scholarly discourse has underscored the efficacy of whole-brain teaching in augmenting children's learning motivation (Abdedulkarim & Ahmed, 2024; Lauc et al., 2020). However, the successful implementation of this methodology is full of challenges, which, if left unaddressed, could impede its effectiveness (Wang et al., 2024). One notable challenge pertains to adaptation limitations, mainly manifested in difficulties associated with sustaining attention. Notably, children in their early developmental stages typically exhibit lower concentration levels.

Therefore, the dynamic and frequently brisk-paced nature inherent in whole-brain teaching strategies may necessitate revision to maintain sustained attention among this demographic cohort. Even so, Whole Brain Teaching in early childhood education has great potential for promoting overall development across the sensory and motor domains by combining activities that involve planning and carrying out tasks of children (Tao & Tao, 2024; Ye et al., 2024). Thus, while duly recognizing its potential merits, addressing the inherent challenges to optimize the implementation of whole-brain teaching within early childhood educational settings is imperative.

Cognitive science development plays a vital role in shaping early childhood education programs. This is due to its significant influence on children's cognitive abilities. Research has shown the malleability of cognitive skills during early childhood, indicating that these abilities are highly responsive to environmental enrichment (Ding et al., 2020). In addition, developing cognitive aspects in early childhood education based on established taxonomies has resulted in identifying specific learning objectives (Astle et al., 2022). According to research by Fong et al. (2023), children prioritize information accuracy over speaker accent when endorsing object labels, emphasizing the importance of content accuracy in children's learning preferences. Research has revealed the flexibility of children's preferences towards similar others, indicating that their learning preferences are adaptable and depend on specific judgments (Vijapur et al., 2021).

The present investigation draws upon a synthesis of extant literature comprising three distinct studies conducted within the preceding year. Firstly, Gore et al. (2021) provide seminal insights into the efficacy of whole-brain teaching methodologies, elucidating the consequential impacts on student engagement and participation. This seminal work underscores the discernible advantages conferred upon students through adopting holistic pedagogical strategies, particularly in fostering heightened student attentiveness and interactive involvement within the educational milieu. Secondly, Cameron et al. (2020) contribute a pivotal examination of the utility of multi-sensory learning environments, with a primary emphasis on visual stimuli. Their findings support the proposition that the judicious integration of visually enriched pedagogical resources augments children's capacity to sustain attention and concentration levels. This corroborative study corroborates the notion that incorporating multi-sensory stimuli, notably visual cues, holds promise for enhancing learners' cognitive engagement and academic performance.

According to Jamil et al. (2021), an educational environment with appropriate cognitive and affective factors can help students understand all learning methods, including measuring children's interest in learning. The study used a descriptive analysis method to compare the components studied. The study concluded that a multi-sensory environment can consistently improve students' learning and skills. Another study by Cosentino and Giannakos (2023) found that a multi-sensory environment produces effective, engaging, and personalized learning for children. This research conducts a literature review to compare and analyze similar studies. The research concluded that, based on the findings of 33 studies reviewed, the interaction and role of a multi-sensory environment can support student interaction in learning. This research introduces a novel approach by investigating the influence of a multi-sensory environment and the entire brain on early childhood cognitive development. The novelty of the method is that this research uses quantitative experiments with a two-way ANOVA, which is novel to the method.

This research is novel as it aims to explore the impact of whole-brain teaching and a multi-sensory environment on cognitive science development, building upon previous studies' findings. Based on this, this research is urgently needed. We urgently need to conduct this research due to its significant relevance and impact on addressing the issue of learning delays in children, particularly in the realm of cognitive science, which encompasses memory, decision-making, and problem-solving. In addition, this research provides understanding and benefits through sharpening theory, the basis for making policies or decisions on applying whole-brain teaching accompanied by multi-sensory environments. This study aims to determine the effect of whole-brain learning and multi-sensory environments on developing cognitive abilities in early childhood.

RESEARCH METHOD

Research Procedure in Flowchart

This study adopts a quantitative methodology utilizing quasi-experimental designs likely in Figure 1.

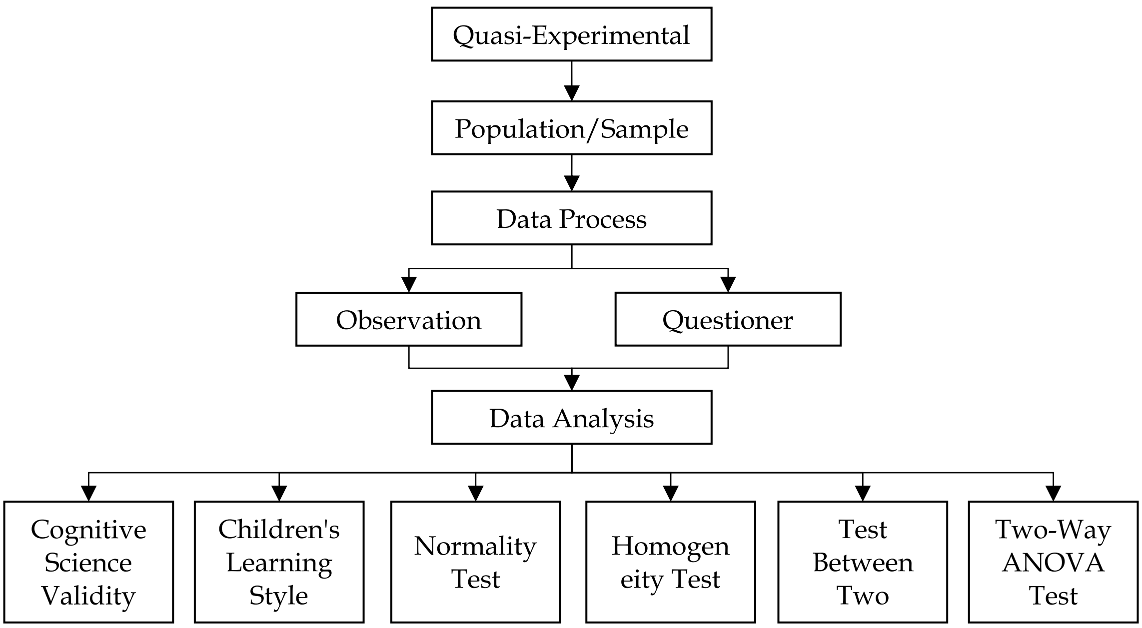

Figure 1. Research procedure.

Quasi-experiments are appropriate here as the research lacks random assignment but includes categorizing participants into groups and involves administering interventions to these groups. The process entailed observing and recording the activities of class B and C students at the State University of Malang Laboratory Kindergarten.

Research Design Notation

The classic experiment:

R O X O
R O   O

Each row represents a group

Description:
R: Random assignment
O: Observation or measure
X: Treatment or intervention
N: Non-equivalent groups

Population, Sample, and Sampling Technique

The State University of Malang Laboratory Kindergarten's classes B and C served as the study's population. We used the purposive sampling technique to obtain 60 children from two groups. The children in these classes were selected because they share the same age characteristics, level of development, and other psychological characteristics. This study can utilize the two classes as experimental subjects.

Data Capture Process

This study collected data through two methods: observation and closed interviews. We conducted observations to evaluate children's cognitive science abilities, encompassing information processing, intelligence, reasoning, language development, and memory. Information processing items include 1) response to visual, audio, and tactile sensory stimuli; 2) ability to pay attention to tasks and stimulus changes; 3) children's capacity to remember; and 4) children's ability to solve cognitive and developmental problems. Intelligence items encompass 1) the child's capacity for abstract and conceptual thinking, 2) the child's recall of teacher-provided information, 3) the child's adaptability, and 4) the child's comprehension of their social environment.

Reasoning items include 1) the child's ability to conclude observations given by the teacher, 2) the child's ability to identify cause-and-effect relationships, 3) the child's ability to understand certain situations in the learning process, and 4) the child's ability to think logically. The following language development items are included: 1) the child's ability to identify the use of new vocabulary; 2) the child's ability to compose vocabulary verbally; 3) the child's ability to understand and compose narrative stories; and 4) the child's ability to respond to information verbally. Memory items include 1) the child's ability to remember information about social relationships and interactions and 2) the ability to remember information quickly. This study employed a four-level scale: Not Developing, Starting to Develop, Developing as Expected, and Developing Very Well. After the initial stage, we carefully conducted a structured, closed interview to identify the main learning styles of children, including visual, auditory, and kinesthetic types. We carefully planned this method to pinpoint critical traits that define each learning style as described by the participants. The interview aimed to clarify the dominant way children receive and handle information by using specific questions, offering essential insights into their unique learning preferences and tendencies.

Table 1. Data processing and analysis procedure.

Methods	Kinesthetic	Auditory	Visual
Control (WBT)	WBT* Kinesthetic	WBT* Auditory	WBT* Visual
Experiment (WBT-MSE)	WBT-MSE* Kinesthetic	WBT-MSE* Auditory	WBT-MSE* Visual

RESULTS AND DISCUSSION

Results

Cognitive Science Validity Test

If the calculated r-value surpasses the r-table, it confirms the validity of the questionnaire indicators. Specifically, if the validity score for each response gathered from the questionnaire list exceeds 0.300, then the question item is considered valid. Table 2 presents data indicating the validity of this study's dimensions and indicators related to cognitive science, as their values exceed 0.300.

Table 2. Results of cognitive science validity test.

Dimensions	Indicator	r-table	r-count
Information Processing	Information gathering	0.250	0.630
	Sorting skills	0.250	0.710
	Processing skills	0.250	0.750
	Perception development	0.250	0.817
	Critical thinking	0.250	0.877
Intelligence	Conscious cognition	0.250	0.937
	Articulation of understanding	0.250	0.921
	Conceptual understanding	0.250	0.905
	Problem articulation	0.250	0.890
	Adaptive learning	0.250	0.874
Reasoning	Logical relations	0.250	0.858
	Cause-effect understanding	0.250	0.843
	Problem-solving skills	0.250	0.827
	Critical analysis	0.250	0.811
	Innovative thinking	0.250	0.796
Language Development	Language acquisition	0.250	0.780
	Effective communication	0.250	0.764
	Language fluency	0.250	0.749
	Listening skills	0.250	0.733
	Multilingual competence	0.250	0.717
Memory	Short-term memory	0.250	0.702
	Long-term memory	0.250	0.686
	Memory consolidation	0.250	0.772
	Memory retrieval	0.250	0.858
	Memory enhancement strategies	0.250	0.944

Child Learning Style Validity Test

The indicators in the questionnaire are considered valid if the calculated r-value is higher than the r-table value. When presenting a list of questions, we deem a question item valid if the validity score for each response exceeds 0.300. Table 3 data analysis validates the dimensions and indicators of children's learning styles in this study, with values exceeding 0.300.

Table 3. Results of cognitive science validity test.

Dimensions	Indicator	r-table	r-count
Visual	Use of visual aids	0.250	0.817
	Preference of infographics	0.250	0.793
	Color-coded information	0.250	0.776
	Engagement with interactive visual media	0.250	0.754
Auditory	Effective use of audiobooks	0.250	0.734
	Participation in oral discussions	0.250	0.713
	Engagement with education podcast	0.250	0.693
	Interactive listening exercises	0.250	0.672
Kinesthetic	Hands-on activities	0.250	0.652
	Learning through physical games	0.250	0.789
	Manipulation of learning tools	0.250	0.926
	Learning through movement-based classes	0.250	0.834

Normality Test

The normality test data is usually distributed if there is no significant difference or if it is standardized compared to the standard normal.

Table 4. Results of normality test.

Variables	Kolmogorov-Smirnov	Sig	Description
(WBT)-Cognitive Science Development	0.943	0.567	Normal
(WBT-MSE)-Cognitive Science Development	0.748	0.775	Normal
(WBT)-Kinesthetic	0.856	0.671	Normal
(WBT)-Auditory	0.654	0.879	Normal
(WBT)-Visual	0.856	0.671	Normal
(WBT-MSE)-Kinesthetic	0.654	0.879	Normal
(WBT-MSE)-Auditory	0.856	0.671	Normal
(WBT-MSE)-Visual	0.654	0.879	Normal

If statistical tests are used, for example, the Kolmogorov-Smirnov test, variables are said to be normally distributed if the significance value is greater than or equal to 0.500. Based on the data processing results in this study, the data are average because all the data tested have a value greater than 0.500.

Homogeneity Test

The normality test data is usually distributed if there is no significant difference or if it is standardized compared to the standard normal. Using statistical tests such as the Kolmogorov-Smirnov test, we define variables as generally distributed if the significance value exceeds or equals 0.500. Based on the data processing results in this study, the data in this study are average because all the data tested have a value greater than 0.500.

Table 5. Results of homogeneity test.

Variables	Levene Statistic	Sig	Description
(WBT)*(WBT-MSE) Cognitive Science Development	3.73	0.746	Homogeneous
(WBT)*(WBT-MSE) Kinesthetic	4.58	0.887	Homogeneous

Variables	Levene Statistic	Sig	Description
(WBT)*(WBT-MSE) Auditory	4.67	0.765	Homogeneous
(WBT)*(WBT-MSE) Visual	5.67	0.764	Homogeneous

If the significance value (P) is equal to or greater than 0.050, the homogeneity test indicates that the variance of two or more groups of measured data is homogeneous. Meanwhile, if the significance value (P) is smaller (<) than 0.050, then the variance of two or more groups of data measured is not homogeneous. Based on the data processing results, this study is known to be homogeneous because all of the data have a value greater than 0.050.

Test Between Two Subjects

The criterion for testing involves making decisions to accept or reject the null hypothesis (Ho) by comparing the α value from the distribution table (critical value) with the value obtained from the statistical test, depending on the type of test used. The data analysis confirms the acceptance of all the tests in this study.

Table 6. Results of the two-subject test.

Group	N	Pretest		Posttest		Gain	
		Mean	Stdev	Mean	Stdev	Mean	Stdev
Control (WBT)	30	47.230	5.900	70.650	6.560	23.420	3.450
Experiment (WBT-MSE)	30	45.980	6.450	82.520	7.370	36.540	4.530
Control Group							
Kinesthetic	9	48.110	6.670	71.650	6.640	23.540	3.250
Auditorial	9	47.320	5.740	68.520	7.830	21.20	4.780
Visual	12	46.890	5.740	70.340	7.540	23.450	4.710
Experiment Group							
Kinesthetic	9	44.110	5.650	81.650	7.710	37.540	3.340
Auditorial	10	45.320	6.650	80.520	6.430	35.20	4.690
Visual	11	45.890	5.320	85.340	7.20	39.450	4.450

Two-Way ANOVA Test

When each sample belongs to a single category, the researcher applies the two-way ANOVA test to assess the hypothesis by comparing k sample means. The researcher also uses a two-way ANOVA when categorizing the samples. Table 6 shows the data analysis results, the learning method shows a significant F value of 5.575, above the threshold of 3.15. In contrast, the learning style has an F value of 1.675, below the critical value of 3.15, indicating it is insignificant. However, the combination of method and learning style is significant because its F value is 4.45, surpassing the 3.15 threshold.

Table 6. Results of the two-subject test.

Dependent Variable: Post Test	Mean	F	Sig.
Learning Methods			
Control (WBT)	23.420	1.675	0.456
Experiment (WBT-MSE)	36.540		
Learning Style			
Kinesthetic	23.540	1.675	0.456
Auditorial	21.200		

Dependent Variable: Post Test	Mean	F	Sig.
Visual	23.450		
*Method * Learning Style*			
WBT* Kinesthetic	23.540	4.45	0.021
WBT* Auditory	21.200		
WBT* Visual	23.450		
WBT-MSE* Kinesthetic	37.540		
WBT-MSE* Auditory	35.200		
WBT-MSE* Visual	39.450		

Discussion

Cognitive Science Development

An empirical inquiry at the State University of Malang Laboratory Kindergarten in Malang City has revealed a statistically significant and affirmative correlation between the advancement of cognitive science and the progression of children's cognitive faculties. This finding corroborates previous studies conducted in analogous domains. The progress of cognitive science development, which is the organized search for understanding the mental processes that support kids' intellectual growth, uses a variety of fields, including cognitive psychology, neuroscience, and linguistics. Piaget's ideas about cognitive development provide a basis for understanding how children build their mental models based on their experiences in the world (Waite-Stupiansky, 2022). Furthermore, studies in cognitive neuroscience, like the one by Fair et al. (2021), help us understand more about the neurobiological bases that support children's cognitive development paths.

Various factors, such as parental attention, parenting style, and environmental stimuli, influence children's cognitive development. Research shows that parental attention significantly impacts children's moral development (Majid, 2023). Furthermore, studies have demonstrated that parenting style and independence positively influence children's social-emotional development (Zarra-nezhad et al., 2022). In addition, attachment between children and parents is also associated with children's behavior (Boldt et al., 2020). The quality of interactions within the family, such as family interaction, social resilience, and marital quality, plays a vital role in shaping children's cognitive and emotional development (Fu et al., 2023). Furthermore, Yafie et al. (2020) stated that incorporating learning multimedia can enhance children's cognitive comprehension in addition to the scientific approach.

Cognitive science development shapes children's thinking ability and overall knowledge acquisition. Understanding the relationship between cognitive science development and children's intellectual growth is critical to optimizing educational strategies and promoting holistic development. Research shows that cognitive science emphasizes critical analysis of the relationship between knowledge and human interests, motives, and contexts that drive the emergence of scientific knowledge (Jamaludin, 2023). This critical analysis shapes how children perceive and interact with information, thus influencing their cognitive development. In addition, research has highlighted the importance of parental knowledge and education in stimulating children's growth and development. There is an essential correlation between parental knowledge, education level, and the stimulation provided to children, which impacts their cognitive development and motor skills (Eliya et al., 2023). In addition, the role of family communication patterns in influencing children's emotional development highlights the link between emotional intelligence and cognitive growth. Effective communication within the family environment fosters understanding and management of emotions, which is integral to cognitive development. In conclusion, the development of cognitive science, parental knowledge, computational thinking, and emotional intelligence all play interconnected roles in shaping children's cognitive growth and overall intellectual development.

Willemsen et al. (2023) have researched vital aspects of cognitive science development, which includes the critical role of memory, language, and reasoning in children's cognitive development. The results of this research bring valuable contributions to our understanding of how children process information, acquire cognitive skills, and develop intellectually throughout the stages of child development. Therefore, cognitive science development positively impacts directing more effective research and educational interventions to support children's cognitive growth. Research has proven that cognitive science development is a rich and complex paradigm for understanding the process of cognitive science development in children. A multidisciplinary approach allows for a more detailed understanding and the formulation of more effective educational interventions. The relationship between significant positive influences, such as parental attention, parenting style, and family interaction, is essential in shaping children's cognitive development and overall well-being.

Children's Learning Preferences

Research at the State University of Malang Laboratory Kindergarten in Malang City has revealed a significant positive relationship or effect between children's learning style preferences and the development of their scientific thinking. Children's learning style preferences significantly impact their scientific thinking development. Visual, auditory, and kinesthetic learning styles are essential to understanding how children receive and process information to gain knowledge and experience (Leasa, 2020). Research shows that different learning styles affect students' motivation and learning achievement. In addition, using learning methods and media tailored to children's learning styles can improve children's speaking and numeracy literacy skills (Mccormick et al., 2020).

Previous studies, such as those conducted by Türker and Bostancı (2023) through the VARK model (Visual, Auditory, Reading/Writing, and Kinesthetic), revealed that there is a tendency for children to have specific learning preferences. These references provide a basis for understanding how selecting learning approaches that match each child's preferences can enhance the processes of information reception and cognitive knowledge construction. Meanwhile, research by Fu et al. (2022) highlighted the importance of audio or auditory approaches in supporting children's cognitive development, where listening and absorbing information through hearing can strengthen children's understanding. Furthermore, research has shown that kinesthetic learning preferences involving physical movement and practical experience positively impact children's understanding and engagement in learning (Halif et al., 2020). Therefore, further research in this area has the potential to shape more effective and inclusive educational practices as well as design teaching strategies that maximize children's cognitive science development according to their learning preferences. According to Gardner's theory of multiple intelligences, each child may have a higher propensity for one or more of these types of intelligence, including visual-spatial intelligence, auditory intelligence, and kinesthetic intelligence (Waterhouse, 2023).

Research by Pan et al. (2021) explains that understanding children's learning preferences can provide essential insights into how they process, store, and recall information effectively. Children with specific learning preferences, such as visual, auditory, or kinesthetic, will be more responsive to learning methods that suit their learning styles (Gola, 2023). In addition, understanding children's learning preferences can also help increase their learning motivation (Haleem et al., 2022). By presenting learning materials to children's learning styles, they will be more engaged in the learning process and have high learning motivation. This will improve learning effectiveness and strengthen children's ability to process, store, and remember information. Understanding children's learning preferences can provide essential insights into how they process, store, and remember information effectively. Children's learning styles, such as visual, auditory, and kinesthetic, play a vital role in the learning process. Additionally, a comfortable and supportive learning environment, such as adequate learning facilities and assistance completing tasks, contributes to learning effectiveness (Chiu, 2021). Parents and teachers who understand children's learning preferences can create a conducive learning atmosphere, provide rewards, and provide necessary assistance. This can increase children's motivation to learn and strengthen the process of storing and remembering information. Understanding children's learning preferences enables using appropriate learning methods like visual, auditory, or kinesthetic-based learning.

Children with visual learning tendencies may be more receptive to images and structured visual presentations. Children with visual learning tendencies may be more responsive to images and structured visual presentations because visual learning styles allow them to process information more effectively through visualization. According to research, visual media, such as images, can help children understand concepts, improve concentration, and strengthen their cognitive abilities (Gever et al., 2021). Using image media in learning can also improve children's creativity, perception, and understanding of the subject matter. In addition, visual media, such as digital flashcards, can help children understand concepts and improve their early reading skills (Cahyati et al., 2022).

In contrast, children with auditory preferences may benefit from a learning approach through oral discussion or explanation. Children with auditory preferences can benefit from a learning approach through oral discussion or explanation because auditory learning involves hearing as the main channel for understanding information. In this context, oral discussion or explanation allows auditory children to listen to information directly, which can enhance their understanding. Research shows that auditory children learn better through listening and oral explanations. This approach allows auditory children to focus on the speaker's voice and intonation, which can help them process information more effectively. Oral discussion or explanation also allows auditory children to actively participate in the learning process by asking questions, responding, and discussing with others. This can increase auditory children's learning engagement and motivation. In addition, this approach can help auditory children hone their listening skills and strengthen their verbal abilities.

In addition, children with kinesthetic learning preferences tend to better understand concepts through hands-on experiences, experiments, or physical involvement in learning. Children with kinesthetic learning preferences tend to better understand concepts through hands-on experiences, experiments, or physical engagement in learning due to kinesthetic learning styles that involve physical movement as the main channel for understanding information. Through hands-on experience and physical engagement, kinesthetic children can grasp abstract concepts with concrete actions, which allows them to understand and remember information better. Research shows that physical movement learning approaches can improve kinesthetic children's concept understanding and information retention (Chong et al., 2023).

Hands-on learning also allows kinesthetic children to hone their motor and sensory skills, supporting a thorough understanding of concepts (Sanfilippo et al., 2022). Through physical experiments and interactions, kinesthetic children can experience concepts firsthand, thus strengthening their understanding of the subject matter. In addition, using kinesthetic approaches in learning can also increase children's learning motivation and strengthen their engagement in the learning process. Therefore, understanding children's learning preferences is critical in designing effective learning strategies that meet the needs of individual children. With the right approach tailored to children's learning styles, the learning process can be more effective, and children can gain a deeper understanding and better retention of information.

CONCLUSION

Fundamental Finding: The research's results indicate that children's learning preferences, such as audio, visual, and kinesthetic learning styles, positively influence the development of cognitive science in their learning process. Cognitive science development positively impacts more effective research and educational interventions, enriching an understanding of how children process information and develop intellectually. **Implications:** This research implies that understanding children's learning preferences can provide crucial insights into how they process, store, and remember information effectively, opening up opportunities for more inclusive and adaptive learning according to each child's cognitive needs. **Limitation:** This research has limitations, namely a narrow scope, so the analysis results only cover narrow objects and subjects of study. **Further research**: This area has the potential to shape more effective educational practices, design teaching strategies that suit children's learning preferences, and understand the development of cognitive science in children's learning.

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