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Gender differences in early childhood natural phenomena recognition: Evidence from Kindergarten Children in Indonesia

Lasmiaty Sianu *, Pupung Puspa Ardini and Irvin Novita Arifin

Master's Program in Primary Education, Graduate School, Universitas Negeri Gorontalo, Indonesia.

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Abstract

The ability to recognize natural phenomena is a fundamental component of early childhood cognitive development because it supports children's scientific thinking through observation, simple reasoning, and environmental exploration. Despite classroom observations suggesting that girls may perform better than boys in science-related activities, empirical evidence regarding gender differences in recognizing natural phenomena remains inconclusive. Therefore, this study aimed to determine whether significant differences exist between boys and girls in their ability to recognize natural phenomena at TK Negeri Kemuning Duhiadaa. This study employed a quantitative experimental approach using a 2 × 2 factorial design. The participants consisted of 44 children aged 5–6 years, including 22 boys and 22 girls, selected through total sampling. Children's ability to recognize natural phenomena was assessed using curriculum-based indicators, and the data were analyzed using two-way analysis of variance at a significance level of 0.05. The results revealed that girls obtained a slightly higher mean score (44.50) than boys (42.77). However, the analysis of variance indicated that the difference was not statistically significant ($F = 1.7107 < F = 4.08$). These findings suggest that boys and girls demonstrate comparable competencies in recognizing changes in shape, color, and odor, identifying simple cause-and-effect relationships, communicating observational findings, and exhibiting scientific attitudes. The results further indicate that gender alone is not a significant determinant of children's ability to recognize natural phenomena, and that equitable learning opportunities and supportive instructional environments are more influential in fostering early scientific competence. In conclusion, this study provides empirical evidence that gender does not significantly affect young children's ability to recognize natural phenomena. The findings contribute to early childhood science education by supporting inclusive instructional practices that provide equal opportunities for scientific exploration and cognitive development regardless of gender.

Keywords: Early childhood education; Gender differences; Natural phenomena recognition; Cognitive development

1. Introduction

Early childhood education constitutes a fundamental stage in human development because it provides the foundation for children's cognitive, social, emotional, and psychomotor growth. During the early years, often referred to as the *golden age*, children experience rapid neurological development that enables them to absorb, organize, and interpret information more efficiently than at any other period of life. One of the essential domains of cognitive development at this stage is children's ability to recognize natural phenomena, which encompasses observing changes in shape, color, and odor, identifying simple cause-and-effect relationships, communicating observational findings, and demonstrating scientific attitudes such as curiosity and openness toward environmental events (Kemendikbud 2024:42–43). According to Piaget's cognitive development theory, children aged 2–7 years are in the preoperational stage, during which symbolic thinking begins to develop and understanding of the surrounding environment is constructed primarily through concrete experiences (Djiwandono 2006:73). These developmental characteristics indicate that early

* Corresponding author: Lasmiaty Sianu

childhood provides an ideal period for cultivating foundational scientific understanding through direct interaction with natural phenomena.

From the perspective of Bloom's revised taxonomy, the competencies involved in recognizing natural phenomena represent the fundamental levels of cognitive functioning that serve as prerequisites for higher-order thinking. The ability to recognize changes in physical characteristics corresponds to the remembering level (C1), identifying simple causal relationships and communicating observations reflect understanding (C2), while demonstrating scientific attitudes represents the application of acquired knowledge (C3) (Anderson, Krathwohl, Aairasian, Cruikshank, Mayer 2001:27–37). These competencies not only facilitate the acquisition of scientific concepts but also promote children's general intellectual development by strengthening curiosity, observational skills, and logical reasoning. Recent developments in early childhood science education emphasize that introducing scientific inquiry from an early age contributes significantly to children's later academic achievement and scientific literacy. Consequently, fostering children's understanding of natural phenomena has become an important objective within contemporary early childhood curricula, particularly as governments increasingly recognize scientific thinking as an essential competency for future generations (Kemendikbud 2024:42–43).

Despite this recognition, substantial differences in children's scientific learning outcomes continue to be reported across early childhood educational settings. Preliminary observations conducted at TK Negeri Kemuning Duhiadaa revealed that many children had not yet demonstrated satisfactory achievement in recognizing natural phenomena, particularly in identifying observable environmental changes, explaining simple causal relationships, communicating observational results, and exhibiting scientific attitudes. More importantly, classroom observations suggested apparent differences between boys and girls in performing these cognitive tasks, with girls appearing to demonstrate relatively stronger performance across several indicators. Such differences raise important educational questions regarding whether children's ability to recognize natural phenomena is influenced by gender or whether these differences merely reflect variations in learning opportunities and classroom experiences. Understanding this issue is particularly important because misconceptions regarding gender-based cognitive abilities may unintentionally shape teachers' expectations and instructional practices, ultimately influencing children's academic development.

Addressing this issue requires a balanced perspective that distinguishes biological variation from educational influences. Theoretical perspectives provide differing explanations regarding gender differences in early cognitive development. The Differential Cortical Maturation Theory suggests that developmental trajectories differ between boys and girls because females generally reach peak cortical maturation earlier than males, potentially influencing cognitive readiness during early childhood (Lenroot, Rhoshel K.; Giedd 2010:9). Similarly, findings reported by ZERO TO THREE indicate that girls tend to exhibit more advanced sensory processing abilities, including visual, auditory, olfactory, and tactile perception during infancy, characteristics that may contribute to greater readiness for observing and interpreting natural phenomena (ZERO TO THREE 2021:3). Nevertheless, these biological perspectives do not imply deterministic differences in scientific ability because cognitive development is also substantially influenced by environmental experiences and educational interventions.

Educational researchers increasingly argue that children's cognitive performance cannot be understood solely through biological maturation. Instead, learning experiences, classroom interactions, and sociocultural influences play equally significant roles in shaping children's academic competencies. Bem's Gender Schema Theory explains that children internalize socially constructed beliefs regarding gender through interactions with their surrounding environment and subsequently use these cognitive schemas to interpret their own abilities, interests, and academic identities (Starr and Zurbriggen 2017:567). Likewise, Vygotsky's sociocultural theory emphasizes that cognitive development emerges through social interaction and guided participation within the Zone of Proximal Development, where appropriate instructional support enables children to achieve higher levels of cognitive functioning than would otherwise be possible independently (Kurniati 2025:19). These theoretical perspectives suggest that any observed differences between boys and girls may result from complex interactions among biological development, social expectations, and educational experiences rather than gender itself.

Previous empirical studies have attempted to examine gender-related differences in early childhood learning; however, the findings remain inconsistent. Several investigations have reported that girls generally demonstrate stronger verbal abilities, greater attention to detail, and more organized learning behaviors, whereas boys often perform better in visual-spatial reasoning and physically oriented exploratory activities (Amin 2018:41–42; Cahaya et al. 2024:311). Other studies have emphasized that girls' relatively advanced language development may facilitate communication, observation, and collaborative learning activities, while boys frequently exhibit stronger preferences for manipulative and exploratory tasks involving concrete objects (Sulistyani 2015:120–133). Although these findings provide valuable

insights into developmental tendencies, they primarily describe general cognitive characteristics rather than children's specific abilities to recognize natural phenomena within structured science learning environments.

Research specifically examining gender differences in early childhood science education remains relatively limited. Existing studies have largely focused on general cognitive development, literacy, creative thinking, or broad scientific competencies rather than the specific construct of recognizing natural phenomena. Furthermore, many previous investigations have emphasized overall developmental outcomes without operationalizing scientific cognition through measurable indicators such as recognizing environmental changes, explaining simple causal relationships, communicating observations, and demonstrating scientific attitudes, as outlined in the current Indonesian Early Childhood Curriculum (Kemendikbud 2024:42–43). Consequently, empirical evidence remains insufficient regarding whether boys and girls actually differ in these foundational science competencies when evaluated using curriculum-based indicators.

Although previous literature has provided valuable theoretical explanations concerning biological maturation, sensory development, language acquisition, and sociocultural influences on gender differences, an important research gap remains. Existing studies generally investigate either overall cognitive development or gender-related learning characteristics independently, whereas relatively few studies specifically examine gender differences in children's ability to recognize natural phenomena within authentic early childhood educational contexts. Moreover, the available literature rarely evaluates this competency using standardized curriculum indicators that integrate observation, causal reasoning, communication, and scientific attitudes into a unified construct. Consequently, uncertainty persists regarding whether apparent classroom differences between boys and girls reflect statistically meaningful cognitive differences or merely observable variations in learning behavior and developmental characteristics.

Based on these considerations, the present study aims to determine whether significant differences exist in the ability to recognize natural phenomena between boys and girls enrolled at TK Negeri Kemuning Duhiadaa. The novelty of this study lies in its exclusive focus on children's competence in recognizing natural phenomena as defined by the current Indonesian Early Childhood Curriculum, rather than broader measures of cognitive development or general science achievement. Furthermore, the study evaluates gender differences using empirically measurable indicators encompassing recognition of changes in shape, color, and odor, understanding of simple cause-and-effect relationships, communication of observational findings, and demonstration of scientific attitudes (Kemendikbud 2024:42–43). Guided by theoretical perspectives from cognitive development, differential cortical maturation, gender schema, and sociocultural learning theories, this study provides empirical evidence regarding whether gender constitutes a significant factor influencing young children's ability to recognize natural phenomena. The findings are expected to contribute to early childhood science education by providing evidence-based guidance for educators in designing equitable instructional practices that support scientific learning for both boys and girls.

2. Methodology

2.1. Research Design

This study employed a **quantitative experimental approach** to examine whether there were significant differences in the ability to recognize natural phenomena between boys and girls enrolled at TK Negeri Kemuning Duhiadaa. Experimental research was selected because it provides the strongest methodological framework for establishing causal relationships by allowing researchers to manipulate independent variables while controlling extraneous variables that may influence the outcome (Fraenkel, Wallen, and Hyun 2012:265). In educational research, experimental methods are not only intended to investigate causal relationships but also to evaluate the effectiveness of instructional interventions under authentic classroom conditions (Creswell 2014:218).

Although the broader research investigated the effects of learning models and gender on children's ability to recognize natural phenomena, the present article focuses exclusively on the second research objective, namely, determining whether significant differences exist between boys and girls in this cognitive competence. Consequently, gender was treated as the primary grouping variable, while the overall experimental structure ensured that gender comparisons were conducted within a controlled instructional context. The general experimental procedures followed the stages recommended by Sugiyono, including formulating research hypotheses, selecting participants, assigning participants to experimental groups, implementing instructional treatments, conducting pre-test and post-test assessments, comparing group outcomes, and statistically analyzing the resulting data to determine the significance of observed differences (Sugiyono 2013:17).

2.2. Research Setting and Participants

The research was conducted at TK Negeri Kemuning Duhiadaa, located in Duhiadaa District, Pohuwato Regency, Gorontalo Province. This school was selected based on both methodological and practical considerations. First, the institution had an adequate number of students to support experimental research. Second, it included Group B children aged 5–6 years, who met the developmental criteria established for the study. Third, the school environment provided appropriate natural surroundings, including gardens, open spaces, and accessible outdoor areas that supported activities related to observing natural phenomena. Finally, the school administration and classroom teachers fully supported the implementation of the research. Creswell emphasizes that research sites should be selected by considering accessibility, data availability, and institutional support to ensure effective implementation of the study (Creswell 2014:135).

The study was conducted during the first semester of the 2025/2026 academic year, specifically from November to December 2025. This period was selected because children had completed their initial school adjustment period, allowing data collection to be conducted under relatively stable cognitive and emotional conditions. In addition, the school schedule permitted uninterrupted implementation of the instructional activities, while favorable weather conditions facilitated observations of natural phenomena in the surrounding environment. Appropriate timing is considered an important factor in maintaining data reliability because participants' readiness and environmental conditions may influence research outcomes (Kustiawan, Raihan, and Thariq 2025:5051).

The research population consisted of all 75 children enrolled at TK Negeri Kemuning Duhiadaa, including both Group A (4–5 years old) and Group B (5–6 years old) students. Population refers to the entire group of individuals possessing characteristics relevant to the research objectives (Sahir 2021:34; Sugiyono 2013:80). Because the ability to recognize natural phenomena requires a sufficient level of cognitive development, the sample was limited to Group B children aged 5–6 years. The final sample comprised 44 children, consisting of 22 boys and 22 girls. A total sampling technique was employed, whereby every child meeting the inclusion criteria was included in the study, ensuring that the sample fully represented the target population within the selected age group (Payadnya and Jayantika 2018:20).

2.3. Experimental Design

The original study employed a 2 × 2 factorial experimental design, involving two independent variables: instructional model (Project-Based Learning and guided inquiry) and gender (boys and girls). Factorial designs are particularly efficient because they enable researchers to examine the individual effects of multiple independent variables while simultaneously testing possible interaction effects (Bhattacherjee 2012:93; Fraenkel et al. 2012:277). The flexibility of the 2 × 2 factorial arrangement also allows either independent variable to be positioned as rows or columns within the design matrix (Oja 2021:1).

Although the complete research examined both instructional model and gender, the present article analyzes only the main effect of gender. Accordingly, the comparison focused on two participant groups—boys and girls—to determine whether statistically significant differences existed in their ability to recognize natural phenomena after participating in the instructional program. The factorial design nevertheless ensured that gender comparisons were evaluated within the same controlled experimental framework, thereby reducing potential confounding influences associated with instructional variation.

2.4. Research Instrument

The dependent variable was **children's ability to recognize natural phenomena**, operationalized according to the Indonesian Early Childhood Curriculum. The assessment instrument measured children's competencies through several observable indicators, including the ability to identify changes in shape, color, and odor, explain simple cause-and-effect relationships, communicate observational findings, and demonstrate scientific attitudes such as curiosity, attentiveness, and openness toward natural events. These indicators collectively represent the construct of recognizing natural phenomena within early childhood science education and served as the basis for evaluating children's cognitive achievement throughout the study.

2.5. Data Analysis

Data analysis was conducted using both descriptive and inferential statistical procedures. Descriptive statistics were first calculated to summarize the distribution of scores for boys and girls. Prior to hypothesis testing, the assumptions required for parametric analysis were evaluated. Data normality was examined before conducting inferential analyses, while the homogeneity of variance assumption was assessed using **Bartlett's homogeneity test**. Homogeneous variance was assumed when the calculated chi-square statistic was smaller than the corresponding critical value,

indicating that the sample groups originated from populations with equivalent variances (Nuryadi et al. 2017:89–90; N. Dantes 2017:42–43).

The principal hypothesis was tested using **two-way Analysis of Variance (ANOVA)**, which is appropriate for factorial experimental designs because it simultaneously evaluates the main effects of each independent variable and their interaction (Payadnya and Jayantika 2018:111). For the purposes of this article, the analysis concentrated on the **main effect of gender**, with the null hypothesis stating that there was no significant difference in the ability to recognize natural phenomena between boys and girls, whereas the alternative hypothesis proposed that gender significantly influenced children's performance. Statistical decisions were made at a **5% significance level (α = 0.05)**. The null hypothesis was retained when the calculated F value was less than or equal to the critical F value, whereas it was rejected when the calculated F value exceeded the critical threshold.

Because the original study also investigated differences associated with instructional models and their interaction with gender, **Tukey's post hoc test** was prepared for situations in which significant ANOVA results were obtained. However, post hoc comparisons were only required for statistically significant effects identified in the overall factorial analysis. Since the present article focuses exclusively on the gender comparison, interpretation is limited to the ANOVA results corresponding to the main effect of gender.

3. Results

3.1. Descriptive Analysis of Children's Ability to Recognize Natural Phenomena by Gender

The second objective of this study was to determine whether boys and girls differed significantly in their ability to recognize natural phenomena at TK Negeri Kemuning Duhiadaa. This objective was formulated based on preliminary classroom observations indicating that girls appeared to demonstrate stronger performance than boys across several indicators of scientific cognition, including recognizing changes in shape, color, and odor, identifying simple cause-and-effect relationships, communicating observational findings, and exhibiting scientific attitudes. However, such classroom observations required empirical verification because observable behavioral differences do not necessarily correspond to statistically significant differences in cognitive achievement. Therefore, inferential statistical analysis was conducted to determine whether gender significantly influenced children's ability to recognize natural phenomena.

Descriptive statistical analysis indicated that the average score of girls was slightly higher than that of boys. The mean score for boys was **42.77**, whereas girls achieved a mean score of **44.50**. Although these descriptive statistics suggest a modest advantage for girls, the difference between the two groups was relatively small. From a practical perspective, both groups demonstrated comparable levels of competence in recognizing natural phenomena, indicating that children of both genders were able to participate successfully in learning activities involving observation, exploration, simple experimentation, and communication of scientific findings.

The relatively similar mean scores also indicate that the learning environment provided opportunities for both boys and girls to engage in scientific exploration. This finding is important because descriptive differences alone cannot be interpreted as evidence of gender inequality. Instead, inferential statistical testing is required to determine whether the observed numerical difference exceeds the level expected from normal sampling variability.

3.2. Hypothesis Testing

The second hypothesis was tested using **two-way Analysis of Variance (ANOVA)** within the factorial experimental design. Although the overall study investigated both instructional model and gender, the present analysis concentrates exclusively on the main effect of gender. The null hypothesis stated that there was no significant difference between boys and girls in their ability to recognize natural phenomena, whereas the alternative hypothesis proposed that gender significantly influenced children's achievement.

The ANOVA results revealed that the **calculated F-value for gender (F = 1.7107)** was substantially lower than the **critical F-value (F = 4.08)** at the **5% significance level (α = 0.05)**. Consequently, the null hypothesis was accepted, indicating that **no statistically significant difference existed between boys and girls in their ability to recognize natural phenomena**. Although girls obtained a slightly higher mean score than boys (44.50 versus 42.77), this difference was insufficient to reach statistical significance. Therefore, the findings indicate that gender did not constitute a significant determinant of children's scientific cognitive performance within the context of this study.

These findings suggest that both boys and girls possessed relatively equivalent competencies in observing natural changes, identifying simple causal relationships, communicating observations, and demonstrating scientific attitudes. Accordingly, children's scientific abilities should not be interpreted through generalized assumptions regarding gender superiority, but rather through their individual learning experiences and developmental opportunities.

4. Discussion

The present findings provide empirical evidence that gender did not significantly influence young children's ability to recognize natural phenomena. Although girls achieved marginally higher average scores than boys, the observed difference was statistically insignificant. This result suggests that the apparent differences initially observed during classroom activities reflected ordinary variation among individual learners rather than systematic cognitive differences attributable to gender.

This finding offers an important contribution to early childhood science education because it challenges common assumptions that girls consistently outperform boys in observational and scientific learning tasks. Initial classroom observations had indicated that girls appeared more attentive during observation activities and more capable of communicating their findings. However, statistical analysis demonstrated that these behavioral tendencies were not accompanied by meaningful differences in overall scientific competence. Consequently, teachers should exercise caution when interpreting classroom behavior as evidence of differences in cognitive ability.

From the perspective of Piaget's cognitive development theory, this finding is theoretically reasonable because all participants belonged to the same developmental stage, namely the preoperational stage. During this period, children construct knowledge primarily through concrete experiences, symbolic representation, and direct interaction with their environment rather than through biological differences associated with gender. Since all participants experienced comparable educational activities within the same school environment, their opportunities for developing scientific understanding were relatively similar. Therefore, developmental stage appears to provide a stronger explanation for children's competence than gender itself.

Similarly, the findings may be interpreted using Bloom's revised taxonomy, which conceptualizes recognition of natural phenomena as involving the cognitive processes of remembering, understanding, and applying knowledge. These foundational cognitive processes are expected to develop through repeated learning experiences rather than being inherently determined by gender. Both boys and girls participated in equivalent classroom activities requiring observation, experimentation, communication, and simple reasoning. Consequently, both groups had similar opportunities to develop the cognitive competencies assessed in this study.

The results also provide an interesting perspective regarding the Differential Cortical Maturation Theory, which proposes that girls generally reach peak cortical maturation earlier than boys, potentially leading to earlier cognitive readiness (Lenroot, Rhoshel K.; Giedd 2010:9). Likewise, findings reported by ZERO TO THREE suggest that girls possess relatively stronger sensory abilities during infancy, including visual, auditory, olfactory, and tactile perception, which theoretically may facilitate observation of natural phenomena (ZERO TO THREE 2021:3). While these theoretical perspectives imply that girls might demonstrate superior performance, the present empirical findings did not support this expectation. The absence of statistically significant differences suggests that biological maturation alone is insufficient to explain children's competence in recognizing natural phenomena. Instead, biological characteristics likely interact with numerous environmental and educational influences that reduce or eliminate potential differences during classroom learning.

These findings further support Bem's Gender Schema Theory, which argues that children's academic behavior is shaped not only by biological characteristics but also by socially constructed expectations regarding gender (Starr and Zurbriggen 2017:567). According to this theory, children gradually internalize cultural beliefs concerning the activities considered appropriate for boys and girls. Nevertheless, when educational environments provide comparable opportunities for exploration and scientific inquiry, these socially constructed expectations may exert only minimal influence on actual learning outcomes. The present findings suggest that the instructional environment at TK Negeri Kemuning Duhiadaa may have provided sufficiently balanced learning opportunities to minimize gender-related differences in scientific achievement.

The results are likewise consistent with Vygotsky's sociocultural theory, which emphasizes that cognitive development emerges through interaction with teachers, peers, and the surrounding cultural environment. Within the Zone of Proximal Development, children's competencies develop through appropriate instructional guidance rather than through biological characteristics alone (Kurniati 2025:19). Since both boys and girls received comparable instructional

support, participated in similar learning activities, and interacted within the same educational environment, equivalent scientific outcomes are theoretically expected. Thus, instructional quality and learning opportunities appear to be more influential than gender in determining children's ability to recognize natural phenomena.

Another important implication concerns the interpretation of previous studies reporting gender-related differences in cognitive development. Earlier investigations frequently concluded that girls demonstrate stronger verbal abilities and greater attention to detail, whereas boys exhibit stronger visual-spatial abilities and preferences for exploratory physical activities (Amin 2018:41–42; Sulistyani 2015:120–133; Cahaya et al. 2024:311). Although these developmental tendencies have been documented in the literature, the present findings indicate that such tendencies should not automatically be generalized to every domain of cognitive performance. The ability to recognize natural phenomena represents a multidimensional scientific competence requiring observation, reasoning, communication, and curiosity. Consequently, successful performance depends on a combination of experiences, instructional support, and developmental readiness rather than on gender-specific characteristics alone.

Furthermore, the present findings differ from the initial research hypothesis, which predicted that girls would demonstrate superior ability in recognizing natural phenomena. This hypothesis was formulated on the basis of theoretical arguments concerning neurological maturation, sensory development, and verbal competence. However, empirical evidence obtained through factorial ANOVA demonstrated that these theoretical expectations were not confirmed within the study population. This discrepancy highlights the importance of distinguishing between theoretical assumptions and empirical findings. While developmental theories provide useful frameworks for generating hypotheses, actual educational outcomes must ultimately be established through rigorous statistical analysis rather than inferred from theoretical expectations alone.

The findings also carry practical implications for early childhood educators. First, teachers should avoid designing science instruction based on assumptions that boys and girls possess fundamentally different capacities for understanding natural phenomena. Instead, instructional planning should emphasize equitable learning opportunities, ensuring that every child is encouraged to observe, explore, ask questions, conduct simple investigations, and communicate scientific findings regardless of gender. Second, assessment practices should prioritize individual achievement rather than gender-based expectations, thereby reducing the possibility of unconscious bias in evaluating children's scientific competencies. Finally, educational interventions intended to improve children's understanding of natural phenomena should focus on enriching learning experiences and instructional quality rather than attempting to accommodate presumed gender differences that may not exist empirically.

Overall, the findings demonstrate that gender was not a statistically significant predictor of children's ability to recognize natural phenomena at TK Negeri Kemuning Duhiadaa. Although girls obtained slightly higher average scores than boys, the difference was neither statistically nor educationally substantial. The results suggest that early childhood science competence develops primarily through meaningful learning experiences, supportive instructional environments, and active engagement with natural phenomena rather than through gender alone. Consequently, educational practices should continue promoting inclusive, inquiry-oriented learning environments that provide equal opportunities for scientific exploration to all children, irrespective of gender.

5. Conclusion

This study investigated whether gender influences young children's ability to recognize natural phenomena at TK Negeri Kemuning Duhiadaa. The findings demonstrated that although girls obtained a slightly higher mean score (44.50) than boys (42.77), the difference was not statistically significant ($F = 1.7107 < F = 4.08$, $\alpha = 0.05$). Therefore, the study concludes that boys and girls possess comparable abilities in recognizing natural phenomena, including observing changes in shape, color, and odor, identifying simple cause-and-effect relationships, communicating observations, and demonstrating scientific attitudes. These findings indicate that gender alone is not a determining factor in children's scientific cognitive development within the context of early childhood education.

The results contribute to the existing body of knowledge by providing empirical evidence that challenges assumptions regarding inherent gender differences in early childhood science learning. While previous theoretical perspectives have suggested that girls may possess developmental advantages associated with neurological maturation, sensory processing, and verbal abilities, the present study demonstrates that such theoretical tendencies do not necessarily translate into significant differences in scientific competence. Instead, the findings highlight the importance of equitable learning opportunities and supportive instructional environments in promoting children's cognitive development regardless of gender.

From a practical perspective, this study suggests that early childhood educators should avoid gender-based assumptions when planning science instruction and assessing children's learning outcomes. Instructional strategies should instead emphasize inclusive, inquiry-oriented learning experiences that encourage active participation by all children. Future research is recommended to investigate gender differences across larger and more diverse populations, incorporate additional cognitive and socio-environmental variables, and employ longitudinal designs to examine whether gender-related differences emerge or diminish throughout subsequent stages of children's scientific development.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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