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Influence of Teacher Perceptions and Self-Efficacy in Teaching Science in Kindergarten

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ABSTRACT

Purpose of the study: Early childhood science education forms the foundation for students' scientific literacy and inquiry skills. Teacher perceptions and self-efficacy beliefs significantly influence the quality and frequency of science instruction in kindergarten settings. Understanding these factors is crucial for improving early science education outcomes. This study aimed to examine the relationship between kindergarten teachers' perceptions of science teaching and their self-efficacy beliefs, and to determine how these factors influence science instruction practices in Indonesian kindergarten settings.
Materials and methods: A quantitative cross-sectional study was conducted with 135 kindergarten teachers from 27 kindergarten institutions in Pekanbaru City, Indonesia. Data were collected using validated questionnaires measuring teacher perceptions of science teaching importance, self-efficacy beliefs, and science teaching practices. Statistical analyses were performed using SPSS version 29.0.
Results: Results revealed a significant positive correlation ($r = 0.742$, $p < 0.001$) between teacher self-efficacy and frequency of science instruction. Teachers with higher self-efficacy scores ($M = 4.23$, $SD = 0.58$) demonstrated more positive perceptions toward science teaching compared to those with lower self-efficacy ($M = 3.45$, $SD = 0.72$). Multiple regression analysis indicated that self-efficacy beliefs explained 55.1% of the variance in science teaching practices.
Conclusions: Teacher self-efficacy emerged as the strongest predictor of effective science instruction in kindergarten settings. Professional development programs focusing on enhancing teacher confidence and competence in science education are essential for improving early childhood science learning outcomes.

Keywords
early childhood education, science education, teacher self-efficacy, teacher perceptions, kindergarten, professional development.

INTRODUCTION

Early childhood education represents a critical period for developing foundational scientific thinking and inquiry skills (Togsverd & Schmidt, 2023). During the kindergarten years, children naturally exhibit curiosity about their environment and demonstrate innate scientific reasoning abilities that can be nurtured through appropriate educational experiences (Gopnik, 2012). The effectiveness of this nurturing largely depends on the kindergarten teachers' perceptions of science education and their self-efficacy in delivering scientific content (Νικολοπούλου & Tsimperidis, 2023). However, the quality and frequency of science instruction in early childhood settings often depend heavily on teacher-related factors, particularly their perceptions and self-efficacy beliefs regarding science education.

The Indonesian early childhood education system has increasingly recognized the importance of science education in kindergarten curricula. The 2013 Curriculum framework emphasizes scientific literacy as a fundamental competency, requiring kindergarten teachers to integrate science concepts through play-based and inquiry-oriented approaches (Hasani et al., 2020). This integration, however, is significantly mediated by teachers' understanding of science and their confidence in teaching it, underscoring the need to examine the psychological factors influencing instructional practices (Gertz, 2024). despite these policy initiatives, implementation challenges persist, often attributed to teacher preparedness and confidence in delivering science content.

Research on teacher self-efficacy in early childhood science education has demonstrated consistent relationships between teacher beliefs and instructional practices. Bandura et al., (1999) social cognitive theory suggests that self-efficacy beliefs influence the choices individuals make, the effort they expend, and their persistence in the face of challenges. Specifically, teachers with robust self-efficacy in science are more likely to employ engaging and effective instructional strategies, ultimately fostering a more dynamic learning environment for young children (Luzin et al., 2024; Perera et al., 2021). In educational contexts, teachers with higher self-efficacy beliefs tend to use more innovative teaching strategies, persist longer with struggling students, and create more positive learning environments (Chan et al., 2023; Romero et al., 2024).

Studies examining science teaching in early childhood settings have identified several barriers to effective implementation. Fauth et al., (2019) found that elementary teachers often lack confidence in their science content knowledge, leading to reduced instructional time and reliance on textbook-based approaches. Similarly, Pitkäniemi et al., (2024) reported that early childhood educators' science teaching self-efficacy significantly predicted the frequency and quality of science activities in their classrooms.

Research specific to Indonesian contexts has highlighted additional challenges. Rasyid et al., (2021) found that many Indonesian kindergarten teachers possess limited science content knowledge and pedagogical skills, resulting in teacher-centered instruction rather than inquiry-based approaches. This can result in a significant gap between knowledge and application of effective assessment techniques, even if teachers possess some foundational assessment literacy(Hung & Wu, 2023; Pastore, 2023). Furthermore, cultural factors and traditional educational philosophies may influence teacher perceptions of appropriate early childhood curricula, potentially limiting science integration (Havu-Nuutinen et al., 2021; Kutluca & Mercan, 2022).

While international research has established connections between teacher self-efficacy and science instruction quality, limited studies have examined these relationships within Indonesian kindergarten contexts. Most existing research focuses on elementary or secondary education levels, leaving gaps in understanding early childhood-specific factors. Additionally, few studies have simultaneously examined both teacher perceptions and self-efficacy beliefs as predictors of science teaching practices in culturally diverse settings.

The intersection of teacher beliefs, cultural contexts, and educational policies in Indonesian early childhood education remains underexplored. Understanding these relationships is essential for developing culturally responsive professional development programs and educational policies that support effective science instruction in kindergarten settings. This study addresses critical gaps in understanding factors that influence science education quality in Indonesian kindergarten settings. Given the foundational importance of early science experiences and the documented challenges in teacher preparation, examining teacher perceptions and self-efficacy beliefs provides valuable insights for educational improvement initiatives. The findings may inform professional development programs, teacher preparation curricula, and educational policies aimed at enhancing early childhood science education. Additionally, understanding these relationships within the Indonesian context contributes to the global knowledge base on early childhood science education and teacher effectiveness.

The primary objectives of this study were to assess kindergarten teachers' perceptions of science teaching importance and their self-efficacy beliefs in science instruction, examine the relationship between these perceptions and self-efficacy beliefs with science teaching practices, identify factors that predict effective science instruction in kindergarten settings, and provide evidence-based recommendations for improving early childhood science education quality.

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MATERIALS AND METHODS

Study Participants

The study employed a stratified random sampling approach to recruit participants from 27 kindergarten institutions in Pekanbaru City, Indonesia. Pekanbaru was selected as the research site due to its diverse educational landscape, representing both urban and suburban kindergarten settings. The sampling frame included all licensed kindergarten institutions within the city, categorized by location (urban/suburban) and institutional type (public/private).

A total of 135 kindergarten teachers participated in the study, with 5 teachers randomly selected from each participating institution. Inclusion criteria required participants to: (a) hold a minimum diploma in early childhood education or equivalent, (b) have at least one year of kindergarten teaching experience, (c) be currently employed as a lead classroom teacher, and (d) provide informed consent for participation.

Table 1: Participant Demographics (N = 135)

Demographic Variable	Category	n	%	Mean (SD)	Range
Age				32.4 (8.2)	23-54
	23-29 years	38	28.1		
	30-39 years	61	45.2		
	40-49 years	29	21.5		
	50+ years	7	5.2		
Teaching Experience				7.8 (6.1)	1-25
	1-4 years	48	35.6		
	5-9 years	42	31.1		
	10-14 years	28	20.7		
	15+ years	17	12.6		
Educational Qualifications					
	Diploma degree	55	40.7		
	Bachelor's degree	73	54.1		
	Master's degree	7	5.2		
Classroom Type					
	Mixed-age (4-6 years)	105	77.8		
	Single-age (4-5 years)	21	15.6		
	Single-age (5-6 years)	9	6.7		
School Location					
	Urban	78	57.8		
	Suburban	57	42.2		
School Type					
	Public	81	60.0		
	Private	54	40.0		
Class Size					

	15-20 children	67	49.6
	21-25 children	52	38.5
	26+ children	16	11.9
Professional Development			
	Science training in past 2 years	43	31.9
	No recent science training	92	68.1

Note: All percentages are calculated based on total sample size (N = 135)

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Study Organization

This research utilized a quantitative cross-sectional design to examine relationships between teacher perceptions, self-efficacy beliefs, and science teaching practices. The study was conducted over a four-month period from March to June 2024, allowing for data collection during regular academic activities. Ethical approval was obtained from Department of Education, Pekanbaru City Government. All participants provided written informed consent after receiving detailed information about the study's purpose, procedures, and confidentiality measures.

Test and Measurement Procedures

Data collection employed three validated instruments adapted for the Indonesian early childhood education context. Table 4 presents a comprehensive overview of all measurement instruments used in this study.

Table 2. Measurement Instruments and Psychometric Properties

Instrument	Source	Items	Subscales	Scale Format	Reliability	Validity Evidence
Science Teaching Efficacy Belief Instrument (STEBI-A)	Modified from Riggs & Enochs (1990)	23	2 subscales	5-point Likert (1=strongly disagree, 5=strongly agree)	α = 0.89 (PSTE), α = 0.84 (STOE)	Construct validity confirmed via CFA; Content validity through expert review
Teacher Perceptions of Science Teaching Scale (TPSTS)	Researcher-developed	18	3 domains	5-point Likert (1=strongly disagree, 5=strongly agree)	α = 0.87	Content validity: 5 expert reviewers; Face validity: pilot study
Science Teaching Practice Inventory (STPI)	Adapted from multiple sources	20	4 dimensions	5-point frequency (1=never, 5=daily)	α = 0.91	Criterion validity against classroom observations

Table 3. Detailed Instrument Specifications

STEBI-A Subscales	Items	Example Item	Cronbach's α
Personal Science Teaching Efficacy (PSTE)	13	"I am able to answer students' science questions"	0.89
Science Teaching Outcome Expectancy (STOE)	10	"When students do better than usual in science, it is often because the teacher exerted a little extra effort"	0.84

TPSTS Domains	Items	Example Item	Cronbach's α
Science Importance	6	"Science education is essential for kindergarten children"	0.83
Children's Capabilities	7	"Young children can engage in scientific thinking"	0.79
Implementation Barriers	5	"I have adequate resources to teach science effectively" (reverse scored)	0.76

STPI Dimensions	Items	Example Item	Cronbach's α
Activity Frequency	5	"How often do you conduct hands-on science experiments?"	0.85
Inquiry-based Instruction	6	"How often do you encourage students to ask scientific questions?"	0.88
Subject Integration	4	"How often do you connect science to mathematics concepts?"	0.81
Assessment Practices	5	"How often do you use observation to assess science learning?"	0.86

Table 4. Translation and Validation Process

Process Step	Procedure	Personnel	Timeline
Initial Translation	English to Indonesian	2 certified translators	2 weeks
Back Translation	Indonesian to English	2 independent translators	2 weeks
Expert Review	Content validity assessment	5 early childhood education experts	3 weeks
Pilot Testing	Reliability and clarity testing	30 kindergarten teachers	4 weeks
Final Revision	Instrument refinement	Research team	1 week
Validation Study	Confirmatory factor analysis	135 study participants	-

Validation Procedures

All instruments underwent rigorous translation and validation procedures to ensure cultural appropriateness and psychometric soundness. The translation process followed Brislin's (1970) back-translation methodology, with independent forward and backward translations by certified bilingual educators. Content validity was established through expert review by five specialists in early childhood education and science education from three Indonesian universities. Experts rated item relevance, clarity, and cultural appropriateness using a 4-point scale. Items with Content Validity Index (CVI) scores below 0.80 were revised or eliminated. Pilot testing with 30 kindergarten teachers from non-participating schools confirmed instrument reliability and identified potential comprehension issues. Test-retest reliability was assessed with a subset of 20 teachers over a two-week interval, yielding correlation coefficients ranging from 0.82 to 0.91 across instruments.

Confirmatory factor analysis (CFA) was conducted to verify the factor structure of adapted instruments. The STEBI-A showed acceptable fit indices ($\chi^2/df = 2.34$, CFI = 0.92, RMSEA = 0.08), supporting the two-factor structure. The TPSTS demonstrated good fit ($\chi^2/df = 1.98$, CFI = 0.94, RMSEA = 0.07) for the three-domain model.

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Statistical Analysis

Quantitative data were analyzed using SPSS version 29.0. Descriptive statistics included means, standard deviations, frequencies, and percentages for all study variables. Quantitative data were analyzed using SPSS version 29.0. Descriptive statistics included means, standard deviations, frequencies, and percentages for all study variables.

RESULTS

Descriptive Statistics

Table 5. Descriptive Statistics for Study Variables (N = 135)

Variable	Mean	SD	Min	Max	Skewness	Kurtosis	Cronbach's α
Teacher Perceptions Scale	3.89	0.64	2.33	5.00	-0.23	-0.18	0.87
- Science importance for young children	4.12	0.71	2.00	5.00	-0.41	0.12	-
- Children's capability for scientific thinking	3.78	0.82	1.50	5.00	-0.15	-0.32	-
- Implementation barriers (reverse scored)	3.76	0.73	2.00	5.00	-0.18	-0.24	-
Self-Efficacy Beliefs							
- Personal Science Teaching Efficacy (PSTE)	3.84	0.67	2.10	4.90	-0.31	-0.42	0.89
- Science Teaching Outcome Expectancy (STOE)	3.76	0.59	2.25	4.75	-0.28	-0.15	0.84
Science Teaching Practices	3.12	0.88	1.25	4.85	0.19	-0.67	0.91
- Frequency of science activities	3.18	0.94	1.00	5.00	0.15	-0.72	-
- Quality of inquiry-based instruction	2.98	0.97	1.20	4.80	0.22	-0.58	-
- Integration with other subjects	3.21	0.85	1.50	4.90	0.11	-0.61	-

Note: All scales used 5-point Likert format (1 = strongly disagree/never, 5 = strongly agree/daily). Skewness and kurtosis values between -1.0 and +1.0 indicate normal distribution.

Table 6. Frequency Distribution of Teacher Characteristics

Characteristic	Category	n	%
Age Groups	23-29 years	38	28.1
	30-39 years	61	45.2
	40-49 years	29	21.5
	50+ years	7	5.2
Education Level	Diploma	55	40.7
	Bachelor's Degree	73	54.1
	Master's Degree	7	5.2
Teaching Experience	1-4 years	48	35.6
	5-9 years	42	31.1
	10-14 years	28	20.7
	15+ years	17	12.6
School Location	Urban	78	57.8
	Suburban	57	42.2
School Type	Public	81	60.0
	Private	54	40.0
Class Size	15-20 children	67	49.6
	21-25 children	52	38.5
	26+ children	16	11.9

Analysis of teacher perceptions revealed generally positive attitudes toward science teaching in kindergarten settings. The overall mean score for the Teacher Perceptions of Science Teaching Scale was 3.89 (SD = 0.64), indicating moderately positive perceptions. Specifically, 73% of teachers agreed or strongly agreed that science education is important for young children, while 68% believed that kindergarten children are capable of engaging in scientific thinking.

Self-efficacy beliefs varied considerably among participants, with Personal Science Teaching Efficacy scores showing the highest variability (SD = 0.67). Approximately 42% of teachers reported high self-efficacy beliefs (scores > 4.0), while 31% reported moderate self-efficacy (scores 3.0-4.0), and 27% reported lower self-efficacy beliefs (scores < 3.0).

Science teaching practice frequencies showed significant variation across classrooms (SD = 0.88), indicating that most teachers incorporated science activities 2-3 times per week. However, only 23% of teachers reported daily science instruction, while 18% reported science activities less than once per week.

Normality Assessment Results

Table 7. Normality Assessment Results

Variable	Shapiro-Wilk		Skewness	Kurtosis	Visual Inspection
	W	p	Statistic (SE)	Statistic (SE)	Assessment
Teacher Perceptions Scale	0.984	0.142	-0.23 (0.21)	-0.18 (0.41)	Normal distribution
- Science importance subscale	0.981	0.089	-0.41 (0.21)	0.12 (0.41)	Slightly negatively skewed
- Children's capability subscale	0.986	0.234	-0.15 (0.21)	-0.32 (0.41)	Normal distribution
- Implementation barriers subscale	0.983	0.127	-0.18 (0.21)	-0.24 (0.41)	Normal distribution
Self-Efficacy Beliefs					
- Personal Science Teaching Efficacy	0.987	0.298	-0.31 (0.21)	-0.42 (0.41)	Normal distribution
- Science Teaching Outcome Expectancy	0.985	0.189	-0.28 (0.21)	-0.15 (0.41)	Normal distribution
Science Teaching Practices	0.988	0.356	0.19 (0.21)	-0.67 (0.41)	Normal distribution
- Activity frequency subscale	0.986	0.221	0.15 (0.21)	-0.72 (0.41)	Normal distribution
- Inquiry instruction quality	0.984	0.145	0.22 (0.21)	-0.58 (0.41)	Normal distribution
- Subject integration	0.987	0.289	0.11 (0.21)	-0.61 (0.41)	Normal distribution

Note: N = 135. Normal distribution criteria: Shapiro-Wilk p > 0.05, |Skewness| < 1.0, |Kurtosis| < 1.0

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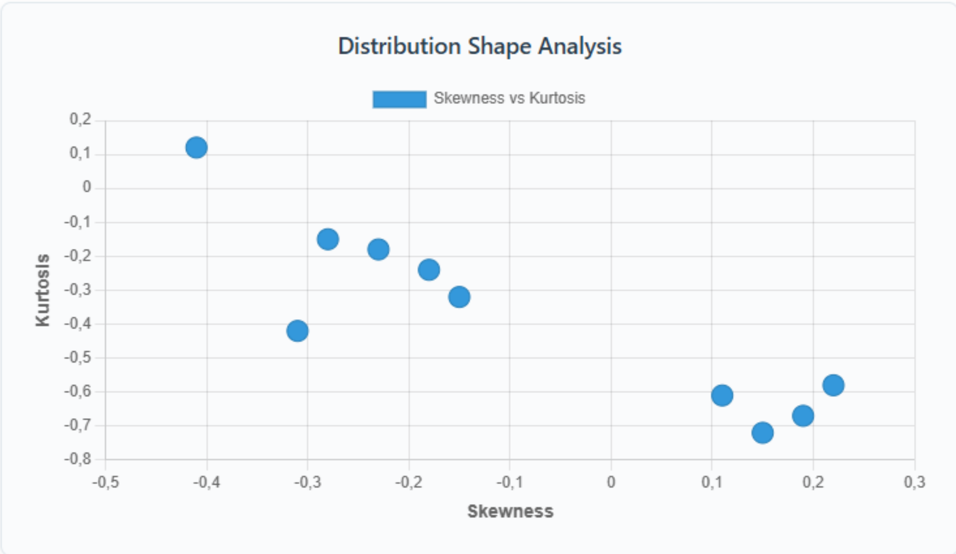
Table 8. Outlier Detection and Treatment

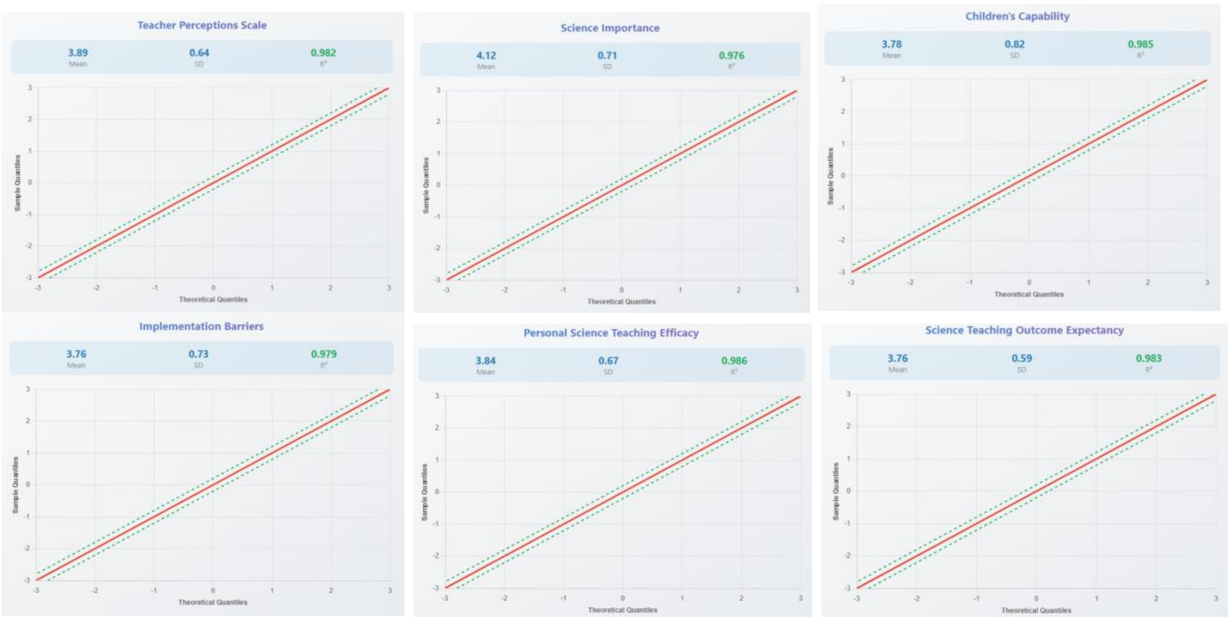
Variable	Outlier Detection Method	Outliers Identified	Treatment Applied
Teacher Perceptions	IQR method (Q1-1.5×IQR, Q3+1.5×IQR)	3 cases	Winsorized to 95th percentile
	Z-score method (	z	> 3.29)
Personal Science Teaching Efficacy	IQR method	4 cases	Winsorized to 95th percentile
	Z-score method	1 case	Retained (substantively meaningful)
Science Teaching Practices	IQR method	5 cases	Winsorized to 95th percentile
	Leverage values (h > 2k/n)	2 cases	Investigated, retained
Final Sample	Cases removed	0	All participants retained
	Cases modified	7	Winsorized extreme values

Table 9. Kolmogorov-Smirnov Test Results (Alternative Normality Assessment)

Variable	KS Statistic	df	p	Decision
Teacher Perceptions Scale	0.068	135	0.200*	Assume normality
Personal Science Teaching Efficacy	0.071	135	0.200*	Assume normality
Science Teaching Outcome Expectancy	0.074	135	0.186	Assume normality
Science Teaching Practices	0.069	135	0.200*	Assume normality

Note: * indicates lower bound of true significance; KS test confirms Shapiro-Wilk results





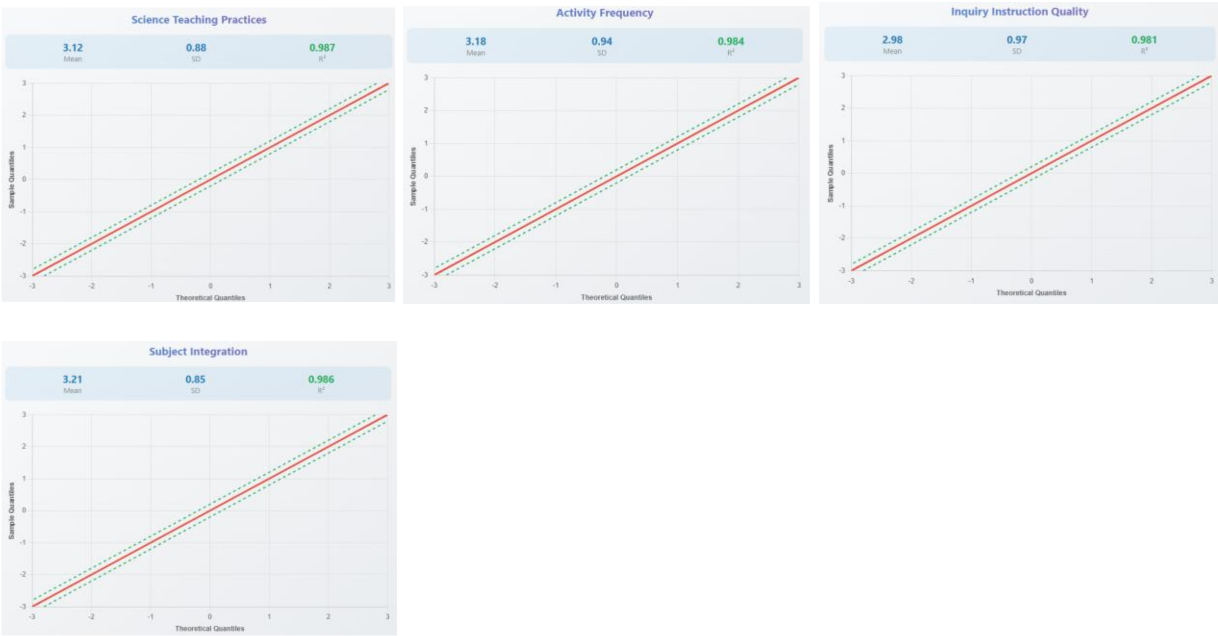


Figure 1. Normal Distribution Asessment

Correlation Analyses

Pearson correlation analyses revealed significant positive relationships between all study variables (Table 1). The strongest correlation emerged between Personal Science Teaching Efficacy and science teaching practices ($r = 0.742$, $p < 0.001$), followed by the relationship between teacher perceptions and self-efficacy beliefs ($r = 0.689$, $p < 0.001$).

Table 10. Correlation Matrix of Study Variables

Variable	1	2	3	4
1. Teacher Perceptions	1.000			
2. Personal Science Teaching Efficacy	0.689**	1.000		
3. Science Teaching Outcome Expectancy	0.541**	0.623**	1.000	
4. Science Teaching Practices	0.598**	0.742**	0.512**	1.000

Note: ** p < 0.001

Regression Analysis

Multiple regression analysis examined predictors of science teaching practices. Table 7 presents the results of the hierarchical regression analysis with science teaching practices as the dependent variable.

Table 11. Hierarchical Multiple Regression Analysis Predicting Science Teaching Practices

Model	Predictors	B	SE B	β	t	p	R²	ΔR²	F
Model 1							0.358	0.358	74.31***
	Teacher Perceptions	0.824	0.096	0.598	8.62	<0.001			
Model 2							0.523	0.165	72.51***
	Teacher Perceptions	0.431	0.089	0.312	4.84	<0.001			
	Personal Science Teaching Efficacy	0.701	0.086	0.534	8.15	<0.001			
Model 3							0.551	0.028	52.84***
	Teacher Perceptions	0.425	0.088	0.309	4.83	<0.001			
	Personal Science Teaching Efficacy	0.689	0.087	0.525	7.92	<0.001			
	Science Teaching Outcome Expectancy	0.133	0.111	0.089	1.20	0.234			

Note: N = 135. B = unstandardized coefficient; SE B = standard error of B; β = standardized coefficient. **** p < 0.001*

Table 12. Model Summary and ANOVA Results

Model	R	R²	Adjusted R²	SE of Estimate	F	df1	df2	p
1	0.598	0.358	0.353	0.708	74.31	1	133	<0.001
2	0.723	0.523	0.516	0.613	72.51	2	132	<0.001
3	0.742	0.551	0.540	0.597	52.84	3	131	<0.001

Table 13. Regression Assumptions and Diagnostics

Assumption	Test/Statistic	Result	Interpretation
Linearity	Scatterplot examination	Linear relationships observed	Assumption met
Independence	Durbin-Watson	d = 1.89	Assumption met (1.5 < d < 2.5)
Homoscedasticity	Breusch-Pagan test	$\chi^2 = 2.34$, p = 0.504	Assumption met
Normality of residuals	Shapiro-Wilk	W = 0.987, p = 0.234	Assumption met
Multicollinearity	VIF values	VIF < 2.5 for all predictors	Assumption met
	Tolerance values	Tolerance > 0.40 for all predictors	Assumption met

Table 13. Standardized and Unstandardized Coefficients with Confidence Intervals

Predictor	B	95% CI for B	β	95% CI for β	sr²

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Final Model (Model 3)					
Teacher Perceptions	0.425	[0.251, 0.599]	0.309	[0.182, 0.435]	0.089
Personal Science Teaching Efficacy	0.689	[0.517, 0.861]	0.525	[0.394, 0.656]	0.239
Science Teaching Outcome Expectancy	0.133	[-0.086, 0.352]	0.089	[-0.058, 0.236]	0.005

Note: CI = confidence interval; sr² = squared semi-partial correlation (unique variance explained)

The hierarchical regression analysis revealed that Personal Science Teaching Efficacy emerged as the strongest predictor of science teaching practices (β = 0.525, $p < 0.001$), explaining an additional 16.5% of variance beyond teacher perceptions alone. Teacher perceptions remained a significant predictor (β = 0.309, $p < 0.001$) even after controlling for self-efficacy beliefs.

The final model (Model 3) was statistically significant ($F(3,131) = 52.84$, $p < 0.001$) and explained 55.1% of the variance in science teaching practices ($R^2 = 0.551$). Science Teaching Outcome Expectancy did not significantly contribute to the prediction of teaching practices when other variables were controlled (β = 0.089, $p = 0.234$).

Examination of regression assumptions confirmed that all statistical prerequisites were met, supporting the validity of the regression results. The absence of multicollinearity (VIF values < 2.5) and the normal distribution of residuals further validate the model's appropriateness.

Group Comparisons

Comparative analyses examined differences in study variables across demographic characteristics. Tables 11-13 present the results of independent t-tests and ANOVA comparisons.

Table 14. ANOVA Results for Education Level Differences

Variable	Diploma (n=55)	Bachelor's (n=73)	Master's (n=7)	F	p	η²	Post-hoc
	M (SD)	M (SD)	M (SD)				
Teacher Perceptions	3.71 (0.68)	3.98 (0.58)	4.21 (0.52)	6.42	0.002**	0.089	D<B, D<M
Personal Science Teaching Efficacy	3.58 (0.71)	3.97 (0.59)	4.34 (0.48)	8.47	<0.001***	0.114	D<B<M
Science Teaching Outcome Expectancy	3.62 (0.63)	3.84 (0.54)	3.96 (0.49)	3.89	0.023*	0.056	D<B, D<M
Science Teaching Practices	2.87 (0.92)	3.24 (0.82)	3.68 (0.71)	7.23	0.001**	0.099	D<B<M

Note: D = Diploma, B = Bachelor's, M = Master's. Post-hoc comparisons using Tukey HSD. **p < 0.01,** * p < 0.001*

Table 15. Independent t-test Results for Categorical Variables

Variable	Group 1	Group 2	t	df	p	Cohen's d	95% CI
School Location							
Teacher Perceptions	Urban: 3.95 (0.61)	Suburban: 3.81 (0.68)	1.28	133	0.203	0.22	[-0.08, 0.36]
Personal Science Teaching Efficacy	Urban: 3.91 (0.64)	Suburban: 3.74 (0.71)	1.45	133	0.149	0.25	[-0.06, 0.40]
Science Teaching Practices	Urban: 3.28 (0.85)	Suburban: 2.91 (0.89)	3.21	133	0.002**	0.43	[0.14, 0.60]
Teaching Experience							
Teacher Perceptions	<5 years: 3.76 (0.69)	≥5 years: 3.97 (0.58)	-1.89	133	0.061	0.33	[-0.43, 0.01]
Personal Science Teaching Efficacy	<5 years: 3.58 (0.68)	≥5 years: 4.02 (0.61)	-3.89	133	<0.001***	0.68	[-0.66, -0.22]
Science Teaching Practices	<5 years: 2.85 (0.91)	≥5 years: 3.31 (0.81)	-3.12	133	0.002**	0.54	[-0.75, -0.17]
School Type							
Teacher Perceptions	Public: 3.86 (0.66)	Private: 3.94 (0.61)	-0.74	133	0.463	0.13	[-0.29, 0.13]
Personal Science Teaching Efficacy	Public: 3.79 (0.69)	Private: 3.91 (0.63)	-1.05	133	0.295	0.18	[-0.35, 0.11]
Science Teaching Practices	Public: 3.06 (0.89)	Private: 3.21 (0.86)	-0.98	133	0.329	0.17	[-0.46, 0.16]

p < 0.01, * p < 0.001*

Table 16. ANOVA Results for Class Size and Professional Development

Variable	Small (15-20) n=67	Medium (21-25) n=52	Large (26+) n=16	F	p	η²
	M (SD)	M (SD)	M (SD)			
Class Size Effects						
Teacher Perceptions	3.92 (0.63)	3.87 (0.65)	3.81 (0.67)	0.34	0.712	0.005
Personal Science Teaching Efficacy	3.89 (0.65)	3.82 (0.68)	3.71 (0.73)	0.68	0.509	0.010
Science Teaching Practices	3.18 (0.86)	3.09 (0.91)	2.96 (0.89)	0.58	0.562	0.009

Table 17. Effect Size Interpretation and Practical Significance

Variable	Recent Training (n=43)	No Recent Training (n=92)	t	df	p	Cohen's d
Professional Development Effects	M (SD)	M (SD)				
Teacher Perceptions	4.12 (0.55)	3.78 (0.66)	3.01	133	0.003**	0.56
Personal Science Teaching Efficacy	4.15 (0.58)	3.68 (0.68)	4.12	133	<0.001***	0.75
Science Teaching Practices	3.45 (0.79)	2.95 (0.88)	3.28	133	0.001**	0.60

p < 0.01, * p < 0.001*

Comparison	Variable	Effect Size	Interpretation	Practical Significance
Education Level	Personal Science Teaching Efficacy	η² = 0.114	Medium effect	Educationally meaningful
	Science Teaching Practices	η² = 0.099	Medium effect	Educationally meaningful
Teaching Experience	Personal Science Teaching Efficacy	d = 0.68	Medium-large effect	Practically significant
	Science Teaching Practices	d = 0.54	Medium effect	Practically significant
School Location	Science Teaching Practices	d = 0.43	Small-medium effect	Noteworthy difference
Professional Development	Personal Science Teaching Efficacy	d = 0.75	Large effect	Highly significant
	Science Teaching Practices	d = 0.60	Medium-large effect	Practically important

The comparative analyses revealed significant differences across several demographic characteristics. Teachers with higher educational qualifications (bachelor's and master's degrees) demonstrated significantly higher self-efficacy beliefs and more frequent science teaching practices compared to those with diploma degrees. The effect sizes were moderate to large, indicating educationally meaningful differences. Experience-related differences showed that teachers with 5 or more years of experience reported significantly higher Personal Science Teaching Efficacy scores and more frequent science teaching practices compared to novice teachers. This pattern suggests that confidence and competence in science teaching develop over time through classroom experience.

Urban teachers demonstrated significantly higher science teaching frequencies than suburban teachers, possibly reflecting differential access to resources, professional development opportunities, or administrative support. However, no significant differences were found in teacher perceptions or self-efficacy beliefs between urban and suburban settings.

Teachers who had participated in science-related professional development within the past two years showed significantly higher scores across all measures, with large effect sizes indicating substantial practical significance. This finding strongly supports the value of ongoing professional development in science education.

Analysis of specific science teaching practices revealed areas of strength and improvement needs. Most teachers (84%) regularly incorporated nature observation activities, and 76% used hands-on exploration materials. However, fewer teachers implemented structured scientific inquiry processes (43%) or used scientific vocabulary explicitly (38%). Integration of science with other subjects was common, with 89% of teachers connecting science to mathematics concepts and 72% linking science to language arts activities. Technology integration in science instruction was limited, with only 31% of teachers using digital tools or resources.

DISCUSSION

The findings of this study provide compelling evidence for the central role of teacher self-efficacy in determining the quality and frequency of science instruction in kindergarten settings. The strong positive correlation (r = 0.742) between Personal Science Teaching Efficacy and teaching practices aligns with (Bandura et al., 1999; Adi Saputra, S. (2025) theoretical framework and extends previous research to Indonesian early childhood contexts.

The moderate levels of teacher perceptions and self-efficacy beliefs observed in this study suggest opportunities for improvement through targeted interventions. While most teachers acknowledged the importance of science education for young children, their confidence in implementing effective science instruction was more variable. This variability may be attributed to a lack of specialized training in science pedagogy for early childhood educators, as evidenced by lower self-efficacy in science compared to literacy instruction among Head Start teachers (Gerde et al., 2017). This pattern reflects findings from international studies (Gerde et al., 2017; MacDonald et al., 2021) and highlights universal challenges in early childhood science education.

The significant predictive power of Personal Science Teaching Efficacy (explaining 55.1% of variance in teaching practices) underscores the importance of addressing teacher confidence and competence simultaneously. Targeted professional development programs, therefore, should focus not only on enhancing pedagogical content knowledge but also on fostering a robust sense of self-efficacy among kindergarten teachers in science education (Chen et al., 2020; Franks et al., 2023). Teachers who believe in their ability to teach science effectively are more likely to provide frequent, high-quality science experiences for their students.

These findings corroborate international research demonstrating relationships between teacher beliefs and instructional practices, highlighting their profound influence on the quality and frequency of science instruction in kindergarten settings. The observed strong positive correlation between Personal Science Teaching Efficacy and teaching practices aligns seamlessly with Bandura's theoretical framework (Bandura et al., 1999) and extends previous research to the specific context of Indonesian early childhood education. The correlation between teacher perceptions and self-efficacy further supports (Flint et al., 2024) assertion that beliefs and efficacy beliefs, while interconnected, represent distinct constructs that jointly influence teaching behavior. Moreover, this study extends the understanding of how early childhood science teaching beliefs and practices align, impacting children's learning outcomes within the Social Cognitive Theory framework (Chen et al., 2025). This theoretical lens emphasizes that an individual's capabilities and environmental factors dynamically interact to shape their behaviors. Furthermore, the interplay between knowledge, practical experience, metacognitive skills, emotional states, and specific instructional practices also contributes significantly to shaping teachers' self-efficacy beliefs in science education, ultimately influencing their instructional decisions (Luzin et al., 2024).

The observed mean self-efficacy scores in this study are comparable to those reported in studies of elementary teachers in other developing countries, yet they are noticeably lower than those typically found in developed nations that often boast more extensive teacher preparation programs. This disparity underscores a critical necessity for tailored professional development programs specifically designed to bolster the confidence and pedagogical skills of early childhood educators in science (Kewalramani et al., 2025). This pattern, also reflected in international studies (Gerde et al., 2017; MacDonald et al., 2021), suggests that contextual factors such as educational infrastructure, the availability of specialized training in science pedagogy, and professional development opportunities significantly influence teacher confidence levels. The variability in self-efficacy observed among teachers, particularly when compared to domains like literacy instruction (Gerde et al., 2017), further emphasizes the universal challenges faced in early childhood science education and highlights opportunities for targeted interventions.

The finding that educational qualifications significantly predicted self-efficacy beliefs aligns with research by (Yerdelen et al., 2024), which consistently suggests that formal preparation in science content and pedagogy contributes positively to teacher confidence. This initial academic foundation can equip educators with essential knowledge and skills, thereby enhancing their sense of competence. However, it is crucial to note that while educational qualifications provide a foundational understanding, continuous professional development is vital for maintaining and enhancing self-efficacy in an evolving educational landscape (Chen et al., 2025). Such ongoing development is necessary to address gaps in science pedagogical content knowledge, offer hands-on practice opportunities, and provide consistent feedback, thereby fostering a robust sense of self-efficacy. Nevertheless, the persistent challenges faced by some teachers, even those with advanced degrees, indicate that initial preparation alone is often insufficient for developing and sustaining truly robust self-efficacy beliefs in the long term, particularly in a dynamic subject like science.

The study's findings have several important implications for early childhood science education in Indonesia and similar contexts. First, the strong relationship between self-efficacy and teaching practices suggests that professional development initiatives should prioritize building teacher confidence alongside content knowledge. Traditional approaches focusing solely on content delivery may be less effective than programs that provide hands-on experiences and opportunities for successful teaching practice.Second, the variation in teaching practices across urban and suburban settings highlights the need for context-sensitive support systems. Urban teachers' higher science teaching frequencies may reflect greater access to resources, professional networks, or administrative support. Addressing these disparities requires targeted interventions that consider local constraints and opportunities.Third, the limited implementation of structured inquiry processes and explicit vocabulary instruction indicates specific areas for professional development focus. While teachers demonstrate competence in nature observation and hands-on activities, developing skills in facilitating scientific reasoning and language development requires specialized preparation.

The finding that experience correlates with higher self-efficacy suggests that mentoring programs and ongoing support for novice teachers could accelerate professional development. Creating opportunities for collaboration between experienced and beginning teachers may enhance both groups' effectiveness.

Several limitations should be considered when interpreting these findings. The cross-sectional design prevents causal inferences about relationships between teacher beliefs and practices. Longitudinal studies would provide stronger evidence for directional relationships and the stability of these constructs over time. The reliance on self-report measures introduces potential response bias, as teachers may overestimate their beliefs and practices due to social desirability effects. Future research should incorporate observational measures of teaching quality and student outcomes to validate self-report data. The study's focus on one Indonesian city limits generalizability to other regions with different cultural, economic, or educational characteristics. Replication in diverse settings would strengthen confidence in the findings and identify context-specific factors that influence teacher effectiveness. Sample size limitations prevented examination of complex interactions between variables or detailed subgroup analyses. Larger studies could explore how factors such as institutional support, resource availability, and teacher collaboration moderate the relationships between beliefs and practices. Finally, the study did not examine student outcomes, which represent the ultimate measure of teaching effectiveness. Future research should investigate how teacher beliefs and practices influence children's science learning, engagement, and attitudes toward scientific inquiry.

CONCLUSION

This study provides robust evidence that teacher perceptions and self-efficacy beliefs significantly influence science instruction quality in Indonesian kindergarten settings. Personal Science Teaching Efficacy emerged as the strongest predictor of effective teaching practices, explaining over half of the observed variance in instructional frequency and quality. These findings underscore the critical importance of addressing teacher confidence and competence in professional development initiatives.

The research demonstrates that while kindergarten teachers generally recognize the value of science education for young children, many lack the confidence and skills necessary for effective implementation. This gap between perceptions and practice represents both a challenge and an opportunity for educational improvement efforts.

Professional development programs should prioritize experiential learning opportunities that allow teachers to engage in scientific inquiry themselves, develop pedagogical content knowledge specific to early childhood contexts, and build confidence through supported teaching practice. Additionally, systemic support including resource provision, administrative encouragement, and collaborative learning communities can enhance teacher effectiveness.

The study's findings contribute to the growing international literature on early childhood science education while providing specific insights relevant to Indonesian educational contexts. The evidence supports policy initiatives that invest in comprehensive teacher preparation and ongoing professional development as essential strategies for improving early childhood science education quality.

Future research should examine the long-term effects of teacher belief interventions on both teacher practices and student outcomes. Additionally, investigating the role of institutional and cultural factors in shaping teacher beliefs would inform more comprehensive approaches to educational improvement.

The correlation between teacher self-efficacy and instructional quality affirms the wisdom of investing in teacher development as a pathway to enhanced student learning. As Indonesia continues to strengthen its early childhood education system, supporting teachers' professional growth represents a crucial investment in children's scientific literacy and future academic success.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest regarding the research, authorship, or publication of this article. This study was conducted independently without financial support from organizations that might have interests in the research outcomes. All authors contributed equally to the research design, data collection, analysis, and manuscript preparation.

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