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The Relationship between Early Childhood Teachers' STEM Attitudes, STEM Practices Self-Efficacy, and Instructional Beliefs: A Mediation Analysis

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ABSTRACT – The successful implementation of Science, Technology, Engineering, and Mathematics (STEM) education in early childhood settings depends largely on teachers' attitudes, instructional beliefs, and confidence in implementing STEM-related practices. Although previous studies have separately examined these constructs, limited evidence is available regarding the mechanisms through which instructional beliefs influence the relationship between STEM practices self-efficacy and teachers' attitudes towards STEM education, particularly within early childhood education. Therefore, this study investigated the relationships among early childhood teachers' attitudes towards STEM education, STEM practices self-efficacy, and instructional beliefs, while examining the mediating role of constructivist instructional beliefs. A quantitative correlational research design was employed involving 211 early childhood teachers from various regions of Türkiye. Participants were selected using convenience sampling. Data were collected using the STEM Education Attitude Scale, the STEM Practices Self-Efficacy Scale, and the Teacher Instructional Beliefs Questionnaire. Pearson correlation analysis, multiple linear regression, and path analysis were conducted using SPSS and AMOS to examine the relationships among the variables and test the proposed mediation model. The findings revealed significant positive relationships between teachers' attitudes towards STEM education, STEM practices self-efficacy, and constructivist instructional beliefs. Traditional instructional beliefs were not significantly associated with teachers' attitudes towards STEM education. Multiple regression analysis demonstrated that STEM practices self-efficacy and constructivist instructional beliefs significantly predicted teachers' attitudes towards STEM education. Furthermore, path analysis indicated that constructivist instructional beliefs partially mediated the relationship between STEM practices self-efficacy and teachers' attitudes towards STEM education. The findings highlight the importance of strengthening teachers' constructivist instructional beliefs alongside STEM teaching competence to promote positive attitudes towards STEM education. The study contributes to the growing body of knowledge on early childhood STEM education by providing empirical evidence of the psychological mechanisms underlying teachers' STEM attitudes.

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INTRODUCTION

The rapid advancement of science and technology has transformed the knowledge, competencies, and skills required for individuals to participate effectively in twenty-first century societies. As technological innovation continues to reshape economic development and labour market demands, education systems worldwide have increasingly prioritised Science, Technology, Engineering, and Mathematics (STEM) education as a strategic approach for developing future-ready citizens. Following the technological competition that emerged after the launch of Sputnik during the Cold War, STEM education evolved from an economic initiative into a comprehensive educational approach aimed at fostering creativity, critical thinking, innovation, and problem-solving skills (Drew, 2011). Today, STEM education is widely recognised as a key driver of national competitiveness and sustainable economic development (Huang, 2008).

Although STEM education initially emerged within secondary and higher education, increasing attention has recently been directed towards its implementation during early childhood. Young children naturally demonstrate curiosity, creativity, and exploratory behaviours that provide a strong foundation for STEM learning (Clements & Sarama, 2018). Rather than focusing solely on disciplinary knowledge, STEM education encourages children to investigate authentic problems, integrate knowledge across disciplines, and construct meaningful understanding through hands-on experiences (Bybee, 2010a; Bybee, 2010b; Simoncini & Lasen, 2018). Consequently, researchers have argued that early exposure to STEM experiences supports children's cognitive, scientific, and problem-solving development while preparing them for lifelong learning (Gonzalez & Kuenzi, 2012; Nayfeld et al., 2013).

Despite the recognised importance of STEM education, successful classroom implementation depends largely on teachers. Early childhood teachers are responsible for designing developmentally appropriate learning environments, integrating STEM concepts into play-based experiences, and facilitating children's inquiry and exploration. Accordingly, teachers' beliefs, attitudes, and confidence substantially influence both the quality and frequency of STEM learning opportunities offered to young children (Brenneman et al., 2019; Capo & Orellana, 2011; Margot & Kettler, 2019). Teachers with stronger STEM self-efficacy are generally more willing to implement STEM-related activities, whereas limited confidence often results in fewer meaningful STEM experiences for children (Elster, 2014; Oppermann et al., 2019).

Instructional beliefs constitute another important factor influencing educational practice. Teachers' beliefs shape their pedagogical decisions, classroom interactions, and interpretations of children's learning processes (Chong et al., 2005; Khader, 2012). Since STEM education is fundamentally grounded in constructivist learning principals, teachers who embrace constructivist instructional beliefs are more likely to facilitate inquiry-based, child-centred, and problem-solving-oriented learning experiences. Conversely, traditional instructional beliefs may limit opportunities for children to actively construct knowledge through exploration and collaboration. Previous studies have demonstrated that teachers' beliefs influence instructional quality, professional decision-making, and children's learning experiences (Chen et al., 2014; Fives & Buehl, 2012; Lee et al., 2004).

Although previous research has separately examined teachers' STEM attitudes, instructional beliefs, and self-efficacy, limited evidence exists regarding how these constructs interact within early childhood education. Existing studies have primarily focused on primary or secondary education, while comparatively fewer investigations have examined the mediating role of instructional beliefs among early childhood teachers (Arnado et al., 2022; Erol, 2021; Yang et al., 2021). Consequently, the psychological processes through which teachers' STEM practices self-efficacy influences their attitudes towards STEM education remain insufficiently understood.

Addressing this gap, the present study examines the relationships between early childhood teachers' STEM practices self-efficacy, instructional beliefs, and attitudes towards STEM education. Specifically, the study investigates whether constructivist instructional beliefs mediate the relationship between STEM practices self-efficacy and teachers' attitudes towards STEM education. By providing empirical evidence from early childhood teachers in Türkiye, this study contributes to a deeper understanding of the factors that support effective STEM implementation and offers practical implications for teacher professional development programmes.

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LITERATURE REVIEW

STEM Education in Early Childhood

STEM education has become a central educational priority worldwide because of its potential to prepare future generations with the competencies required to address increasingly complex scientific, technological, and societal challenges. Rather than treating science, technology, engineering, and mathematics as separate disciplines, STEM education promotes interdisciplinary learning that encourages children to integrate knowledge, apply problem-solving skills, and develop creative solutions to authentic situations (Bybee, 2010a; Bybee, 2010b).

Within early childhood education, STEM learning extends beyond introducing scientific concepts. Instead, it provides opportunities for children to explore, investigate, experiment, and construct knowledge through meaningful play-based experiences. Young children naturally demonstrate curiosity and a desire to understand their surroundings, making early childhood an appropriate period for developing scientific thinking and inquiry skills (Clements & Sarama, 2018). Consequently, effective STEM education should encourage active participation, exploration, collaboration, and critical thinking rather than rote memorisation.

Researchers have consistently reported that early STEM experiences contribute positively to children's cognitive development, creativity, reasoning abilities, and future academic achievement (Gonzalez & Kuenzi, 2012; Nayfeld et al., 2013). Furthermore, STEM education supports children's ability to integrate knowledge across disciplines while simultaneously fostering communication, collaboration, and innovation skills required in the twenty-first century workforce (Simoncini & Lasen, 2018). These findings highlight the importance of introducing STEM education during the early years as a foundation for lifelong learning.

Despite these recognised benefits, successful STEM implementation depends largely on teachers who translate curriculum intentions into meaningful classroom practices. Accordingly, teachers' knowledge, beliefs, confidence, and attitudes remain fundamental determinants of children's STEM learning experiences.

Teachers' Attitudes Towards STEM Education

Teachers' attitudes represent one of the strongest predictors of classroom practice because they influence instructional decisions, motivation, and willingness to adopt educational innovations. Positive attitudes towards STEM education encourage teachers to integrate interdisciplinary learning experiences into their classrooms, whereas negative attitudes often reduce the frequency and quality of STEM instruction (Capo & Orellana, 2011).

Within early childhood education, teachers with positive attitudes are generally more willing to design inquiry-based learning activities, encourage children's curiosity, and create environments that promote experimentation and collaborative problem-solving (Margot & Kettler, 2019). Conversely, teachers who perceive STEM as difficult or beyond their competence may avoid implementing STEM-related activities despite recognising their educational value.

Previous research has demonstrated that teachers' attitudes are closely associated with professional confidence, prior STEM experiences, and perceived competence (Elster, 2014; Oppermann et al., 2019). These findings suggest that improving teachers' attitudes requires not only strengthening STEM content knowledge but also enhancing confidence in applying STEM pedagogies within authentic classroom settings.

STEM Practices Self-Efficacy

Self-efficacy refers to an individual's belief in his or her capability to successfully perform a particular task or behaviour. Within STEM education, teachers' STEM practices self-efficacy reflects their confidence in planning, implementing, and evaluating STEM learning activities effectively.

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Teachers possessing higher levels of self-efficacy are more likely to experiment with innovative instructional strategies, persist when encountering classroom challenges, and demonstrate greater enthusiasm towards STEM teaching. In contrast, teachers with limited self-efficacy frequently avoid STEM activities due to uncertainty regarding their instructional competence (Elster, 2014).

Research has consistently demonstrated positive relationships between teachers' self-efficacy and instructional quality (Oppermann et al., 2019). Teachers who believe they possess the necessary knowledge, and pedagogical skills generally exhibit greater commitment towards implementing STEM education and are more likely to create meaningful learning opportunities that promote children's scientific inquiry and problem-solving skills.

Accordingly, STEM practices self-efficacy represents an important psychological factor that may directly influence teachers' attitudes towards STEM education while simultaneously shaping their instructional behaviours.

Teachers' Instructional Beliefs

Teachers' instructional beliefs influence how they interpret teaching, learning, and children's cognitive development. These beliefs shape classroom decisions, instructional strategies, curriculum implementation, and teacher-student interactions (Fives & Buehl, 2012; Khader, 2012).

Constructivist instructional beliefs emphasise active learning, inquiry, collaboration, and children's active construction of knowledge. Teachers adopting constructivist perspectives generally encourage children to investigate problems, ask questions, and develop understanding through exploration rather than direct instruction. Such pedagogical orientations align closely with the philosophical foundations of STEM education.

Conversely, traditional instructional beliefs emphasise teacher-directed instruction, knowledge transmission, and structured classroom management. Although such approaches may remain appropriate in certain educational contexts, they provide fewer opportunities for children to engage in inquiry-based STEM experiences that require exploration, creativity, and collaborative problem-solving. Previous studies have demonstrated that teachers' instructional beliefs influence both instructional quality and classroom implementation of educational innovations (Chen et al., 2014; Lee et al., 2004). Consequently, understanding teachers' instructional beliefs provides important insights into the factors influencing STEM implementation in early childhood classrooms.

The Relationship Between STEM Self-Efficacy, Instructional Beliefs, and Teachers' Attitudes

Although previous studies have independently examined teachers' STEM attitudes, instructional beliefs, and self-efficacy, relatively limited research has investigated the relationships among these variables within a single conceptual framework.

Teachers with stronger STEM self-efficacy generally demonstrate more positive attitudes towards STEM education because confidence enhances willingness to implement innovative instructional approaches. At the same time, instructional beliefs may influence how teachers translate confidence into classroom practice. Teachers possessing constructivist beliefs are more likely to apply their STEM competence through inquiry-based teaching approaches, whereas traditional instructional beliefs may weaken this relationship.

This interaction suggests that instructional beliefs may function as an important psychological mechanism linking STEM practices self-efficacy with teachers' attitudes towards STEM education. However, empirical evidence examining this mediating relationship among early childhood teachers remains limited, particularly within the Turkish educational context (Arnado et al., 2022; Erol, 2021; Yang et al., 2021).

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Research Gap and Conceptual Framework

Despite increasing international interest in early childhood STEM education, several important research gaps remain. Existing studies have primarily focused on examining direct relationships between teachers' attitudes, self-efficacy, and instructional beliefs. Comparatively fewer studies have investigated the underlying mechanisms explaining how these variables interact to influence teachers' attitudes towards STEM education.

Furthermore, research examining the mediating role of constructivist instructional beliefs among early childhood teachers remains limited. Understanding this mechanism is important because teachers' beliefs influence not only what they teach but also how they design learning experiences that support children's STEM development.

Accordingly, this study proposes that constructivist instructional beliefs mediate the relationship between STEM practices self-efficacy and early childhood teachers' attitudes towards STEM education. By testing this mediation model, the study contributes to a more comprehensive understanding of teachers' psychological readiness for STEM implementation and provides empirical evidence that may inform future teacher education and professional development programmes.

METHOD

Research Design

This study employed a quantitative correlational research design to investigate the relationships among early childhood teachers' attitudes towards STEM education, STEM practices self-efficacy, and instructional beliefs. In addition, the study examined the mediating role of constructivist instructional beliefs in the relationship between STEM practices self-efficacy and teachers' attitudes towards STEM education.

A correlational design was considered appropriate because the study sought to determine the magnitude and direction of relationships among the study variables without manipulating the research environment. Furthermore, mediation analysis was conducted to examine whether constructivist instructional beliefs functioned as an explanatory mechanism linking teachers' STEM practices self-efficacy with their attitudes towards STEM education.

Participants

The participants comprised 211 early childhood teachers working in preschool education settings across Turkiye. Participants were selected using a convenience sampling technique, allowing researchers to recruit teachers who met the inclusion criteria and voluntarily agreed to participate in the study. Table 1 summarises the demographic characteristics of the participants.

Table 1. Demographic Information of Teachers

Demographic Variables		*f*	%
Gender	Female	198	93.8
	Male	13	6.2
Age	20-24 years old	49	23.2
	25-29 years old	64	30.3
	30-34 years old	54	25.6
	35-39 years old	19	9.0
	40 + years old	25	11.8
Professional Experience	1-5 years	90	42.7
	6-10 years	54	25.6
	11-15 years	30	14.2
	16 + years	37	17.5

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Overall, the participants represented diverse teaching backgrounds and professional experience, providing an appropriate sample for examining teachers' perceptions of STEM education within early childhood settings

RESEARCH INSTRUMENTS

Three validated instruments were employed to collect data.

STEM Education Attitude Scale

Teachers' attitudes towards STEM education were measured using the STEM Education Attitude Scale. The instrument assesses teachers' overall perceptions, interest, and willingness to implement STEM education in early childhood classrooms. Higher scores indicate more positive attitudes towards STEM education.

STEM Practices Self-Efficacy Scale

Teachers' confidence in implementing STEM learning activities was measured using the STEM Practices Self-Efficacy Scale. The scale evaluates teachers' perceived capability to design, facilitate, and assess STEM learning experiences appropriate for young children. Higher scores represent stronger STEM instructional self-efficacy.

Teacher Instructional Beliefs Questionnaire

Teachers' instructional beliefs were measured using the Teacher Instructional Beliefs Questionnaire, comprising two dimensions:

- Constructivist instructional beliefs
- Traditional instructional beliefs

The constructivist dimension reflects teachers' preferences for inquiry-based, child-centred learning, whereas the traditional dimension reflects teacher-centred instructional orientations.

Validity and Reliability

Prior to data collection, the psychometric properties of the research instruments were examined to ensure their suitability for the present study.

Construct validity was evaluated using Confirmatory Factor Analysis (CFA), while internal consistency reliability was assessed using Cronbach's alpha coefficients.

The results demonstrated satisfactory validity and reliability across all measurement scales, indicating that the instruments were appropriate for assessing teachers' attitudes towards STEM education, STEM practices self-efficacy, and instructional beliefs.

Data Collection Procedure

Data were collected through structured questionnaires administered to early childhood teachers. Prior to participation, respondents were informed about the objectives of the study, voluntary participation, confidentiality of responses, and anonymity throughout the research process. Only teachers who provided informed consent completed the questionnaire. Completed questionnaires were screened before analysis to ensure completeness and accuracy.

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Data Analysis

The collected data were analysed using IBM SPSS Statistics and AMOS. Descriptive statistics were first computed to summarise participants' demographic characteristics. Pearson Product-Moment Correlation analysis was conducted to examine the relationships among teachers' attitudes towards STEM education, STEM practices self-efficacy, constructivist instructional beliefs, and traditional instructional beliefs.

Multiple Linear Regression analysis was subsequently performed to determine the predictive contributions of STEM practices self-efficacy and instructional beliefs towards teachers' attitudes. Finally, Structural Equation Modelling (SEM) using AMOS was employed to test the hypothesised mediation model.

The mediation analysis examined whether constructivist instructional beliefs significantly mediated the relationship between STEM practices self-efficacy and teachers' attitudes towards STEM education. Statistical significance was determined at the $p < .05$ level.

Ethical Considerations

The study adhered to established ethical principles governing educational research. Participation was entirely voluntary. Participants were informed about the purpose of the study prior to completing the questionnaire and were assured that all responses would remain anonymous and confidential. The collected data were used exclusively for academic research purposes and reported only in aggregate form to protect participants' identities.

RESULTS AND DISCUSSION

Demographic Characteristics of Participants

A total of 211 early childhood teachers participated in this study. The respondents represented diverse demographic backgrounds in terms of age, teaching experience, educational qualifications, and professional status, providing a comprehensive overview of teachers involved in early childhood education across Turkiye. Table 1 presents the demographic characteristics of the participants.

Table 1. Demographic Information of Teachers

Demographic Variables		*f*	%
Gender	Female	198	93.8
	Male	13	6.2
Age	20-24 years old	49	23.2
	25-29 years old	64	30.3
	30-34 years old	54	25.6
	35-39 years old	19	9.0
	40 + years old	25	11.8
Professional Experience	1-5 years	90	42.7
	6-10 years	54	25.6
	11-15 years	30	14.2
	16 + years	37	17.5

The demographic profile indicates that the participants possessed varied professional experiences, thereby providing a suitable representation for examining teachers' attitudes towards STEM education, STEM practices self-efficacy, and instructional beliefs.

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Relationship Between STEM Practices Self-Efficacy, Instructional Beliefs and Teachers' Attitudes Towards STEM Education

To address the first research objective, Pearson Product-Moment Correlation analysis was conducted to examine the relationships among STEM practices self-efficacy, constructivist instructional beliefs, traditional instructional beliefs, and teachers' attitudes towards STEM education. Table 2 presents the correlation coefficients among the study variables.

Table 2. Correlation analysis results (N=211)

Variables	1	2	3	4
1. Attitude towards STEM Education	1			
2. STEM Practices Self-Efficacy	.275*	1		
3. Traditional Beliefs	-.079	.006	1	
4. Constructivist Beliefs	.261*	.252*	-.072	1

**p<.01*

The results revealed statistically significant positive correlations between STEM practices self-efficacy and teachers' attitudes towards STEM education. Similarly, constructivist instructional beliefs demonstrated a significant positive relationship with teachers' attitudes, indicating that teachers who possessed stronger constructivist beliefs tended to report more favourable attitudes towards STEM education.

Conversely, traditional instructional beliefs exhibited either weak or non-significant relationships with teachers' attitudes, suggesting that teacher-centred instructional orientations were less compatible with effective STEM implementation in early childhood education.

These findings indicate that teachers' confidence in implementing STEM activities and their preference for constructivist pedagogical approaches are positively associated with favourable attitudes towards STEM education.

DISCUSSION

The positive relationship between STEM practices self-efficacy and teachers' attitudes supports previous research suggesting that teachers who perceive themselves as competent are more willing to implement innovative instructional approaches (Elster, 2014; Oppermann et al., 2019). Self-efficacy enhances teachers' confidence in overcoming instructional challenges and encourages greater engagement with interdisciplinary STEM learning.

Similarly, the significant relationship between constructivist instructional beliefs and STEM attitudes reinforces the theoretical foundations of constructivist learning. STEM education requires children to actively investigate problems, collaborate with peers, and construct understanding through inquiry-based learning. Consequently, teachers who embrace constructivist beliefs are naturally more receptive towards STEM implementation than those who rely predominantly on teacher-centred instructional approaches.

Predictors of Teachers' Attitudes Towards STEM Education

To determine the predictive influence of STEM practices self-efficacy and instructional beliefs on teachers' attitudes towards STEM education, Multiple Linear Regression analysis was conducted. The regression model is presented in Table 3.

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Table 3. Multiple linear regression analysis results

Independent variables	B	S.H	β	t	p	dual r
Constant	37.932	5.111		7.422	.000*	
Constructivist Beliefs	.635	.217	.198	2.921	.004*	.199
Self-Efficacy	.073	.022	.223	3.302	.001*	.224
Traditional Beliefs	-.080	.080	-.066	-1.006	.315	-.070
R= .34, R^2=.12, F= 9.26, p<.01						

**p<.01*

The analysis demonstrated that STEM practices self-efficacy significantly predicted teachers' attitudes towards STEM education. Constructivist instructional beliefs also emerged as a significant predictor, whereas traditional instructional beliefs did not contribute significantly to the prediction model.
Collectively, these findings suggest that teachers' confidence in implementing STEM activities and their constructivist instructional orientations are important determinants of positive attitudes towards STEM education.

Discussion

These findings indicate that positive attitudes towards STEM education are shaped by both psychological competence and pedagogical beliefs. Teachers who possess greater confidence in facilitating STEM learning are more likely to perceive STEM education positively because they believe they possess the necessary knowledge and instructional skills to implement STEM successfully.

Furthermore, constructivist instructional beliefs strengthen teachers' willingness to create inquiry-based learning environments that align closely with the principles of STEM education. The non-significant contribution of traditional instructional beliefs further highlights the incompatibility between teacher-centred pedagogy and the interdisciplinary, inquiry-oriented nature of STEM education.

These findings are consistent with previous studies reporting that instructional beliefs substantially influence classroom practices and teachers' adoption of educational innovations (Chen et al., 2014; Fives & Buehl, 2012).

Mediating Role of Constructivist Instructional Beliefs

To address the final research objective, Structural Equation Modelling (SEM) was performed using AMOS to examine whether constructivist instructional beliefs mediated the relationship between STEM practices self-efficacy and teachers' attitudes towards STEM education.

The model demonstrated satisfactory goodness-of-fit indices, indicating that the proposed mediation model adequately represented the observed data.

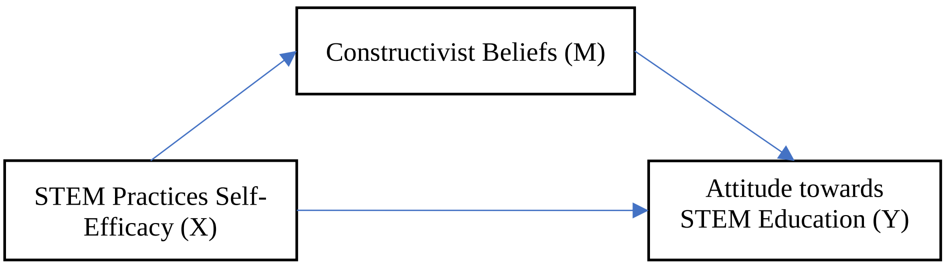

Figure 1. The mediator effect model proposed in the research

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The path analysis further revealed that constructivist instructional beliefs significantly mediated the relationship between STEM practices self-efficacy and teachers' attitudes towards STEM education.

Specifically, teachers possessing stronger STEM practices self-efficacy were more likely to develop constructivist instructional beliefs, which subsequently enhanced their positive attitudes towards STEM education.

Discussion

The mediation findings represent the principal contribution of this study.
Although previous research has demonstrated direct relationships between self-efficacy and STEM attitudes, the present study extends existing knowledge by demonstrating that constructivist instructional beliefs function as an important psychological mechanism through which self-efficacy influences teachers' attitudes.

This finding suggests that self-efficacy alone may not be sufficient to promote positive attitudes towards STEM education. Rather, teachers' pedagogical beliefs determine how instructional confidence is translated into classroom practice.

Teachers who possess high self-efficacy but continue to embrace traditional instructional approaches may be less likely to implement authentic STEM learning experiences. In contrast, teachers who combine strong instructional confidence with constructivist beliefs are more likely to design child-centred, inquiry-based STEM activities that promote children's active engagement and problem-solving.

These findings reinforce constructivist learning theory, which argues that meaningful learning occurs when children actively construct knowledge through exploration, experimentation, and collaboration.

From a practical perspective, the findings indicate that professional development programmes should move beyond strengthening STEM content knowledge alone. Equal emphasis should be placed on developing teachers' constructivist pedagogical beliefs to ensure that increased instructional confidence is translated into effective STEM classroom implementation.

Summary of Findings

Overall, the findings demonstrate that STEM practices self-efficacy, constructivist instructional beliefs, and teachers' attitudes towards STEM education are closely interconnected.

Teachers possessing stronger confidence in implementing STEM learning were more likely to adopt constructivist instructional beliefs, which subsequently enhanced their positive attitudes towards STEM education.

In contrast, traditional instructional beliefs did not significantly contribute to teachers' attitudes, suggesting that teacher-centred pedagogical orientations are less compatible with contemporary STEM education practices.

Most importantly, the mediation analysis provides empirical evidence that constructivist instructional beliefs represent an important explanatory mechanism linking teachers' instructional confidence with their attitudes towards STEM education. These findings contribute to a more comprehensive understanding of teachers' psychological readiness for effective STEM implementation in early childhood education.

CONCLUSION

This study examined the relationships between early childhood teachers' attitudes towards STEM education, STEM practices self-efficacy, and instructional beliefs, while investigating the mediating role of constructivist instructional beliefs. The findings revealed that teachers' STEM practices self-efficacy and constructivist instructional beliefs were positively associated with favourable attitudes towards STEM

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education. In contrast, traditional instructional beliefs did not significantly predict teachers' attitudes, suggesting that teacher-centred pedagogical orientations are less compatible with effective STEM implementation in early childhood settings.

One of the most significant findings of this study is the identification of constructivist instructional beliefs as a partial mediator between STEM practices self-efficacy and teachers' attitudes towards STEM education. This finding extends existing knowledge by demonstrating that teachers' instructional confidence alone is insufficient to foster positive attitudes towards STEM education. Instead, teachers' pedagogical beliefs play a crucial role in transforming instructional competence into positive perceptions and effective classroom implementation.

The findings contribute both theoretically and practically to the field of early childhood STEM education. From a theoretical perspective, the study provides empirical evidence supporting the interconnected roles of self-efficacy, instructional beliefs, and teacher attitudes in explaining STEM implementation. From a practical perspective, the findings suggest that professional development initiatives should simultaneously strengthen teachers' STEM competencies and constructivist pedagogical beliefs to promote sustainable STEM practices in early childhood classrooms.

Despite these contributions, several limitations should be acknowledged. The study employed a convenience sampling strategy involving early childhood teachers from Türkiye; therefore, the findings should be interpreted within this context and may not be generalisable to other educational settings. Furthermore, the cross-sectional nature of the study limits causal interpretation of the observed relationships.

Future research should consider employing longitudinal or mixed-methods designs to further explore the dynamic relationships among teachers' beliefs, instructional practices, and attitudes towards STEM education. Comparative studies across different countries and educational systems may also provide valuable insights into contextual factors influencing STEM implementation in early childhood education.

Overall, the study demonstrates that developing teachers' constructivist instructional beliefs alongside STEM practices self-efficacy represents a promising strategy for strengthening teachers' attitudes towards STEM education and supporting the successful implementation of STEM learning experiences in early childhood classrooms.

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CONFLICT OF INTEREST

The authors declare that there are no financial, professional, or personal conflicts of interest that could have influenced the work reported in this manuscript.

AUTHORS' CONTRIBUTION

A. Erol: conceptualization, methodology, investigation, formal analysis, data curation, writing including original draft, project administration.

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Y. Anders: validation, supervision, writing including review and editing.
H. G. Rossbach: conceptualization, supervision, validation, writing including review and editing.

AVAILABILITY OF DATA AND MATERIALS

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

DECLARATION OF GENERATIVE AI

During the preparation of this manuscript, the authors used ChatGPT (OpenAI) solely to improve the clarity, grammar, and readability of the manuscript. Following the use of this tool, the authors carefully reviewed and edited the content and took full responsibility for the final version of the manuscript.

ETHICS STATEMENT

Participation in this study was voluntary. Prior to data collection, all participants were informed about the objectives of the research, and informed consent was obtained from each participant. Respondents were assured that all information would remain confidential and anonymous, and that participation could be withdrawn at any stage without any consequences. Ethical approval: Not applicable.

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