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Science learning motivation and teacher-student relationships in early childhood education: Evidence from Thailand and Japan

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ABSTRACT

This study investigates the influence of teacher-student relationships on young children's motivation to learn science in diverse cultural contexts. Specifically, it examines three key motivational indicators: science self-concept, science liking, and ease of learning science among preschool and early primary school students in Japan and Thailand. The total number of participants was 169 children (ages 4-8), including 108 from Japan and 61 from Thailand. Data was collected using questionnaires and analyzed with hierarchical multiple regression and multivariate analysis of variance (MANOVA). The study focused on how three dimensions of teacher-student relationships (closeness, negative expectations, and conflict) affect the science motivation of children. The results showed that closeness with teachers was the strongest predictor of all three indicators. However, student conflict and negative expectations were significantly associated with lower motivation levels. Japanese students have significantly higher scores on all motivational outcomes than Thai students. This suggests that cultural and educational contexts may influence early motivation for science learning. The findings also highlighted the importance of fostering emotional support and trust in teacher-student relationships for early science education across different cultures. Promoting positive relationships from the preschool level may enhance long-term interest in science among young children and confidence in their learning, regardless of cultural background.

Contribution/Originality: This study contributes to existing literature by exploring the teacher-student relationship and students' motivation in science learning across two cultural contexts. The findings provide new insights into how these relationships differ between Japan and Thailand. Japanese students reported more teacher conflicts, greater confidence, and found science easier than Thai students.

1. INTRODUCTION

Early childhood is a critical period in which motivational beliefs and self-concept begin to form, influencing later academic engagement and career aspirations (Chan, Maneewan, & Koul, 2023b; Locke, 1997). Previous studies have emphasized the importance of teacher-student relationships (TSR) in shaping children's learning behaviors (Knowles, Murray, & Gau, 2024). Supportive and close relationships promote positive outcomes, while conflict and negative expectations are associated with maladaptive learning patterns (Koomen & Jellesma, 2015; Pianta & Ryan, 2002; Pianta, 1999). Motivation toward science, encompassing science self-concept, enjoyment, and perceived ease, has been

recognized as an essential foundation for sustained engagement in STEM fields (Mantzicopoulos, Patrick, & Samarapungavan, 2008; Schraw & Lehman, 2001). However, much of the existing research has focused on older students or Western educational settings, leaving a gap in understanding how these processes operate in early childhood and across diverse cultural contexts. Cultural values and educational practices, such as the emphasis on academic achievement in East Asian societies, may further shape children's motivation and self-beliefs.

To address these research gaps, the study examined the dimensions of teachers-student relationships (closeness, negative expectations, and conflict) related to young children's science learning in Japan and Thailand.

2. LITERATURE REVIEW

2.1. Motivation in Early Childhood

Early childhood is widely recognized as a sensitive period for the development of motivation and self-perceptions. Previous studies emphasize that self-efficacy plays a significant role in children's early lives and influences their persistence in academic tasks (Bandura, 1997; Schunk & Mullen, 2012). Similarly, Eccles and Wigfield (2002) noted that motivational beliefs formed during preschool and primary school years have long-term effects on academic choices and career aspirations. Moreover, Mantzicopoulos et al. (2008) reported that young children's motivational beliefs, including self-concept and enjoyment, can predict engagement in learning activities.

2.2. Teacher-Student Relationships (TSR)

Teacher-student relationships play a crucial role in shaping children's motivation and socio-emotional development (Quin, 2017; Yoshimoto, Murakami, & Osamu, 2023). Studies by Pianta (1999) showed that supportive relationships foster positive academic outcomes, whereas conflict or negative interactions can undermine children's confidence and achievement. A meta-analysis from Roorda, Koomen, Spilt, and Oort (2011) confirmed that positive teacher-student relationships enhance students' engagement and motivation, while conflict decreases academic self-concept. Recent studies have highlighted that teacher expectations, warmth, and socio-emotional support substantially influence children's enthusiasm for learning (Leighton, Guo, Chu, & Tang, 2018; Villaseñor, 2017).

2.3. Motivation in Science Education

Research in science education has increasingly focused on how motivational constructs such as self-concept, interest in science, and perceived ease of learning science develop in early childhood. Patrick, Mantzicopoulos, and Samarapungavan (2009) found that integrating inquiry-based approaches in kindergarten sustained motivation with minimal gender differences at this level. Schraw and Lehman (2001) argued that situational interest, closely linked to perceiving ease and enjoyment, is central to maintaining science motivation. However, much of the existing research has been related to older learners or Western educational contexts. Science motivation in early childhood remains underexplored.

2.4. Cross-Cultural Perspectives

Motivation and teacher-student interactions are influenced by cultural values and educational practices. Markus and Kitayama (1991) and Hofstede (2001) demonstrated that cultural orientations, such as collectivism and individualism, shape self-concepts and motivational processes. Schneider and Lee (1990) reported that East Asian classrooms often emphasize academic rigor, which can foster high achievement motivation, whereas relational-oriented classroom cultures may place greater emphasis on harmony and emotional support than on academic competition. Few studies have compared how teacher-student relationships influence early science motivation across different cultural settings (Lay & Ng, 2021).

2.5. Research Gap

In summary, previous studies highlight (a) the foundational role of early motivation, (b) the significant influence of teacher-student relationships, (c) the importance of sustaining interest in science from a young age, and (d) the cultural specificity of motivational processes. Nevertheless, little research has integrated these themes within the context of early science education, particularly through cross-cultural study. To address this gap, the present study investigates how teacher-student relationships, specifically closeness, negative expectations, and conflict, affect science motivation among preschool and primary school children in Japan and Thailand.

Motivation during early childhood and the primary school years plays a critical role in shaping children's long-term academic attitudes and their future educational and career choices. According to Bandura's social cognitive theory, self-efficacy and motivation developed during early life stages are strong predictors of future learning engagement and persistence in academic tasks (Schunk & Mullen, 2012). Moreover, various longitudinal studies in developmental psychology have demonstrated that early motivational experiences, particularly shaped by interpersonal relationships, can influence cognitive, emotional, and behavioral regulation in schools. This is particularly relevant in science education, where early experiences often determine whether children view science as accessible and enjoyable or difficult and irrelevant to them. As global societies emphasize the importance of STEM education, understanding how to foster science learning motivation at an early age remains a significant challenge for educators and researchers (Sugita McEown, Sawaki, & Harada, 2017).

However, this challenge remains: how can educators foster these motivations to influence cultural and educational contexts? Existing research often overlooks how culturally specific teaching practices and classroom norms can shape students' emotional responses to science learning. Among the many factors that influence children's motivation, the quality of teacher-student relationships has been attracting growing attention. Prior studies have demonstrated that emotionally supportive and trusting teacher-student interactions enhance motivation, academic performance, and socioemotional development (Leighton et al., 2018; Villaseñor, 2017). On the other hand, conflict and negative expectations in teacher-student relationships have been associated with lower levels of engagement and diminished academic self-concept (Quin, 2017). Regardless of these findings, there is still little consensus on how to measure and improve teacher-student relationships effectively in real-world settings. Various assessment tools such as observation-based rubrics (e.g., CLASS), self-report questionnaires (e.g., STRS), and video-based reflection programs have been used internationally. However, their cultural adaptability and long-term effectiveness remain under-researched. Additionally, teacher-student relationships often rely on individual experiences and emotional skills of educators, which creates challenges for reproducibility and scalability. Moreover, existing research has mainly focused on older students, while limited attention has been given to how these relationships are observed in preschool and early primary school settings. Furthermore, most existing studies have been conducted within a single cultural or national context. Few have compared the dynamics of teacher-student relationships and science motivation in international settings or across different cultural backgrounds. As a result, our understanding of how relationships develop and influence young children's learning, particularly in science, remains limited. Early childhood, being a sensitive period for emotional and cognitive development, requires focused investigation that integrates both developmental psychology and pedagogical perspectives. Cross-cultural research faces additional methodological challenges in ensuring that measurement tools capture equivalent constructs across contexts. Furthermore, intervention studies aimed at improving teacher-student relationships in multicultural classrooms are rare, and few of these have provided clear evidence of long-term improvements in students' motivation. Given that educational practices and expectations vary significantly across cultures, cross-cultural comparisons are essential for identifying both universal and culture-specific patterns in student motivation and interactions with teachers (Hofkens, Pianta, & Hamre, 2023). To fill these gaps, our study adopts a quantitative approach that relies on structured questionnaires. Because the participants were very young children, the questionnaires were completed by their teachers on their behalf. This method allows us to capture both relational and motivational aspects of early

learning environments. By integrating developmental psychology with cross-cultural educational research, this study contributes to a more comprehensive understanding of how interpersonal relationships in early learning environments shape science motivation.

Therefore, this study aims to examine the following research questions.

RQ1. What are the relationships among countries, gender, teacher-student relationships, and science learning?

RQ2. How do teacher-student relationships influence science motivation in early childhood?

3. METHODOLOGY

3.1. Participants

A total of 169 children between 4 and 8 years of age participated in the study. This sample comprised 108 children from Japan (including both preschool and early primary school students) and 61 children from Thailand (all attending preschool). The gender distribution was approximately balanced across the sample. Participants were recruited using convenience sampling, selecting children from schools and classes that were readily accessible to the researchers. Parental consent was obtained for all participants, and ethical approval for the research was secured through each participating school's administration. All procedures were conducted in accordance with ethical standards for research with young children. We created a survey and requested cooperation from two international schools in Japan, Universal Kids Yokohama and Harmony International School, as well as Universal Kids Bangkok in Bangkok, Thailand. Data was collected from educators in teaching positions, and we received their cooperation.

3.2. Measures

Teacher-student relationships: We assessed the quality of teacher-student relationships using an adapted version of the Student-Teacher Relationship Scale (STRS). This instrument evaluates three relationship dimensions: closeness (emotional warmth and open communication), negative expectations (teacher's pessimistic or critical outlook toward the child), and conflict (friction or discord in the relationship). In consideration of the participants' young age, the questionnaires were filled out by their teachers on their behalf.

Science Learning Motivation: Children's motivation in science was measured using scales adapted from Mantzicopoulos et al. (2008) covering science self-concept (children's confidence in their science ability), liking for science (enjoyment and interest in science activities), and perceived ease of learning science (how easy the child feels science is to learn). These scales have been used in prior research on early childhood science education and were culturally adapted for use in Japan and Thailand. All scales demonstrated high internal consistency in this study, with Cronbach's alpha values ranging approximately from 0.78 to 0.95, indicating reliable measurement of the constructs.

3.3. Data Analysis

Data were analyzed using both regression and group comparison techniques. Hierarchical Multiple Regression: We conducted three separate hierarchical regressions (one for each science motivation outcome: self-concept, liking, and ease of learning). Predictors were entered in blocks: Step 1 included child demographics (e.g., age group, gender), Step 2 added country (Japan vs. Thailand) to capture cultural context, and Step 3 introduced the teacher-student relationship variables (closeness, negative expectations, conflict). This approach allowed us to examine the unique contribution of teacher-student relationships to science motivation after accounting for age and cultural context. MANOVA (Multivariate Analysis of Variance): We performed a one-way MANOVA to test for differences between the Japanese and Thai student groups on the set of key variables (the three teacher-student relationship dimensions and the three science motivation indicators). This analysis evaluated whether countries (as a fixed factor) had a significant multivariate effect on relationship quality and motivational outcomes, and follow-up ANOVAs were examined for each individual variable.

3.4. Effect Sizes

To complement significance testing, we calculated effect sizes to gauge the practical significance of our findings. For the regression models, we report R^2 values indicating the proportion of variance explained. For group differences (Japan vs Thailand), we report measures such as eta-squared (η^2) from the MANOVA/ANOVA and Cohen's d for pairwise comparisons, where relevant, to indicate the magnitude of differences observed.

4. RESULTS

Before presenting the detailed results, this section provides an overview of the main findings from both the regression and group comparison analyses. The results highlight how teacher-student relationship dimensions (closeness, negative expectations, and conflict) are associated with children's science motivation, and whether these patterns differ between Japan and Thailand. Descriptive statistics and correlations are first presented, followed by hierarchical regression analyses examining the unique contributions of teacher-student relationship variables.

Table 1. List of measurement instruments.

Variables	Number of items	Source	Scales	Cronbach's alpha
Teacher-student relationships		Koomen and Jellesma (2015)	5-point Likert Scale	
Closeness	9			0.81
Negative expectations	10			0.78
Conflict	10			0.91
Science learning		Mantzicopoulos et al. (2008)		
Science self-concept	7			0.95
Science liking	6			0.95
Ease of science	4			0.94

Table 1 shows that the measurement scales used in this study were based on previous research concerning teacher-student relationships and students' science learning, consisting of a 46-item questionnaire administered to 169 preschool and elementary school students. The results of the internal reliability analysis showed Cronbach's alpha coefficients ranging from .78 to .95 across all scales, confirming strong internal consistency (Roorda et al., 2011). For the teacher-student relationship construct, the scale developed by Koomen and Jellesma (2015) was adopted, which includes three subscales: closeness, negative expectations, and conflict. These dimensions have been widely recognized in educational psychology as important indicators of relationship quality (Pianta, 1999), and a positive teacher-student relationship has been shown to significantly influence students' academic and social development (Roorda et al., 2011). In the present study, Cronbach's alpha coefficients for these subscales ranged from .78 to .91, indicating high internal consistency. For students' science learning, subscales based on the work of Mantzicopoulos et al. (2008) were used, including science self-concept, science liking, and ease of learning science. These constructs reflect motivational and cognitive factors that influence young children's interest in and engagement with science and are affected by gender and learning environments (Patrick et al., 2009). Furthermore, Schraw and Lehman (2001) emphasized that situational interest is strongly related to students' perceptions of enjoyment and ease of learning, which aligns with the conceptual foundation of the "ease of learning science" scale.

Table 2. Intercorrelations among study variables: country, gender, teacher-student relationships (closeness, negative expectations, conflict), and science learning (science self-concept, science liking, ease of science) (n = 169).

Variables	1	2	3	4	5	6	7	8
1. Country		-0.044	-0.081	-0.054	0.250**	0.470**	0.417**	0.374**
2. Gender			0.080	-0.012	-0.321**	0.028	-0.008	0.015
3. Closeness				-0.302**	-0.293**	0.250**	0.340**	0.317**
4. Negative expectations					0.341**	-0.269**	-0.369**	-0.408**
5. Conflict						-0.143	-0.207**	-0.225**
6. Science self-concept							0.904**	0.876**
7. Science liking								0.899**
8. Ease of science								

Note: **p < 0.01.

Regarding RQ1, which examines the relationships among countries, gender, teacher-student relationships, and science learning, the results are demonstrated in Table 2. Table 2 shows intercorrelations for the study variables: country, gender, teacher-student relationships (closeness, negative expectations, and conflict), and science learning (science self-concept, science liking, and ease of science). Country was positively associated with conflict and teacher-student relationships (science self-concept, science liking, and ease of science). Gender was negatively associated with conflict. Closeness was positively associated with science learning (science self-concept, science liking, and ease of science). Conflict was positively associated with negative expectations. However, there was a negative association between negative expectations and science learning (science self-concept, science liking, and ease of science), and a negative association between conflict and science learning (science liking and ease of science). There was a low to high correlation between the significant variables, ranging from 0.250 to 0.904.

According to RQ2, which examines how teacher-student relationships influence motivation across cultural contexts and gender, country was positively associated with conflict and teacher-student relationship variables (closeness, negative expectations, and conflict), and gender was negatively associated with conflict. Conflict was positively associated with negative expectations. However, there was a negative association between negative expectations and science learning (science self-concept, science liking, and ease of learning science), and a negative association between conflict and science learning (science liking and ease of learning science). There was a low to high correlation between the significant variables, ranging from 0.250 to 0.904. The study used hierarchical regression analyses to identify the influence of variables on science learning (science self-concept, science liking, and ease of learning science) as shown in Table 3 - 5.

Table 3. Results of hierarchical regression analyses: predictors of science self-concept (n = 169).

Influence variables	Science self-concept		
	Model 1	Model 2	Model 3
Gender	0.28	0.051	-0.028
Country		0.474**	0.523**
Teacher-student relationships			
Closeness			0.209**
Negative expectations			-0.117
Conflict			-0.181*
R^2	0.001	0.225	0.357

Note: *p < 0.05, **p < 0.01. Only standardized coefficients are reported.

4.1. Science Self-Concept

Table 3 shows the effect of gender, country, and teacher-student relationships (closeness, negative expectations, and conflict) on science self-concept is analyzed. Country, closeness, and conflict explained the most variance in science self-concept in model 3. Country was the best predictor of science self-concept, along with closeness and conflict. The detailed explanation of the table is as follows.

Hierarchical regression analysis identified significant predictors of children's science self-concept. In model 1 (with only demographic controls), gender had a positive but non-significant effect on science self-concept ($\beta = 0.280$, $p > .05$), suggesting that boys and girls did not differ notably in confidence about science when considered alone. Adding the country in Model 2 significantly improved the model's explanatory power (increasing R^2 from 0.001 to 0.225). Country emerged as a strong predictor of science self-concept ($\beta = 0.474$, $p < 0.01$), indicating that, on average, children's confidence in science differed by cultural context. In the final Model 3, which included teacher-student relationship factors, two relational variables were significant: closeness showed a positive effect ($\beta = 0.209$, $p < 0.01$) and conflict showed a negative effect ($\beta = -0.181$, $p < 0.05$) on science self-concept. Negative expectations had a negative coefficient as well ($\beta = -0.117$) but did not reach statistical significance. The full model explained about 35.7% of the variance in science self-concept ($R^2 = 0.357$). In summary, children who experienced warm, supportive relationships with their teachers tended to have higher science self-concepts, whereas those experiencing higher

teacher-child conflict had lower self-concepts in science. These findings align with prior research emphasizing that emotionally secure teacher-child relationships bolster young children's academic confidence (Pianta, 1999). Additionally, the significant country effect suggests that cultural context plays a critical role in shaping children's self-beliefs in science (Lee, 2009). Educators should note that nurturing positive teacher-student relationships, while also being mindful of cultural learning environments, is vital for developing children's self-efficacy in science (Frenzel, Pekrun, & Goetz, 2007; Marsh & Martin, 2011; Wang & Holcombe, 2010).

Table 4. Results of hierarchical regression analyses: Predictors of science liking (n = 169).

Influence variables	Science liking		
	Model 1	Model 2	Model 3
Gender	-0.004	0.016	-0.079
Country		0.422**	0.476**
Teacher-student relationships			
Closeness			0.262**
Negative expectations			-0.192**
Conflict			-0.209**
R^2	0.000	0.178	0.403

Note: **p < 0.01. Only standardized coefficients are reported.

4.2. Science Liking

Table 4 shows that the country was a significant predictor of science liking in model 2. In the final model, country, closeness, negative expectations, and conflict explained the most variance in science liking. Country was the strongest predictor of science liking, along with closeness, conflict, and negative expectations.

In the initial regression model, gender had virtually no effect on liking for science (β = -0.004, $R^2 \approx 0.000$), indicating that boys and girls in this age group expressed equivalent levels of enthusiasm for science activities. This is consistent with recent observations that gender gaps in early STEM interest are minimal or narrowing (Wang & Degol, 2017). Introducing the country in Model 2 led to a substantial increase in explained variance (R^2 = 0.178). Country was a significant positive predictor of science liking (β = 0.422, p < .01), underscoring the influence of sociocultural context, such as differences in science curricula and classroom climate, on children's interest in science (Schneider & Lee, 1990). In Model 3, adding the teacher-student relationship variables further improved the model (final R^2 = 0.403). Closeness again had a strong positive effect on liking for science (β = 0.262, p < .01), suggesting that children who feel close to their teacher are more emotionally engaged and find science more enjoyable. In contrast, negative expectations from the teacher (β = -0.192, p < 0.01) and teacher-child conflict (β = -0.209, p < 0.01) both showed significant negative effects on science liking. In other words, when teachers harbor pessimistic expectations or frequently conflict with a child, the child's enjoyment of science tends to diminish. These findings are consistent with the work of Roorda et al. (2011), who identified positive emotional connections with teachers as a driver of student motivation, and with Yoon (2002), who reported that teacher-related stressors can undermine students' enthusiasm for learning.

Table 5. Results of hierarchical regression analyses: predictors of ease of science (n = 169).

Influence variables	Ease of science		
	Model 1	Model 2	Model 3
Gender	0.015	0.034	-0.056
Country		0.376**	0.421**
Teacher-student relationships			
Closeness			0.232**
Negative expectations			-0.253**
Conflict			-0.194*
R^2	0.000	0.141	0.380

Note: *p < 0.05, **p < 0.01. Only standardized coefficients are reported.

4.3. Ease of Learning Science

Table 5 reports that the country was a significant predictor of ease of learning science in model 2. In model 3, country, closeness, negative expectations, and conflict explained the most variance in ease of learning science. Country was the best predictor of ease of learning science, along with closeness, negative expectations, and conflict. The details are explained below.

To investigate students' perception of the ease of learning science, a third regression analysis was conducted. In model 1, gender alone was not a significant predictor ($\beta = 0.015$, $R^2 = 0.000$). In model 2, the country had a significant effect ($\beta = 0.376$, $p < 0.01$), increasing R^2 to 0.141. This supports research by Schneider and Lee (1990) and Stigler and Hiebert (2009), who argued that national instructional styles and expectations shape students' confidence. Model 3 incorporated the teacher-student relationship variable, increasing the model's explanatory power to $R^2 = 0.380$. Here, country remained the strongest predictor ($\beta = 0.421$, $p < 0.01$), followed by closeness ($\beta = 0.232$, $p < 0.01$), negative expectations ($\beta = -0.253$, $p < 0.01$), and conflict ($\beta = -0.194$, $p < 0.05$). These results demonstrate that students' perception of how manageable science is depends not only on national education structures but also on relational experiences. This aligns with Locke's (1997) theory of self-efficacy, which posits that emotional encouragement and verbal support foster students' belief in their academic abilities. Moreover, Eccles and Wigfield (2002) argued that the perception of task difficulty is shaped by both social expectations and interpersonal interactions, especially those with teachers (O'Connor & McCartney, 2007). It also emphasizes the negative academic effects of strained relationships. Thus, emotionally supportive and low-conflict classroom environments are essential for cultivating confidence in science learning. A similar pattern of results was found for children's enjoyment of science (Chang, Faikhamta, Na, & Song, 2018).

Table 6. Results of analysis of variance: means and standard deviations of variables in Thailand and Japan (n = 169).

Variables	Thailand		Japan		Country difference	
	M	SD	M	SD	F value	Eta-squared
Teacher-student relationships						
Closeness	4.03	0.46	3.94	0.61	1.12	0.007
Negative expectations	1.99	0.69	1.92	0.56	0.50	0.003
Conflict	1.43	0.48	1.86	0.95	11.06**	0.062
Motivation for science learning						
Science self-concept	3.39	0.75	4.15	0.65	47.47**	0.221
Science liking	3.62	0.72	4.28	0.69	35.06**	0.174
Ease of science	3.57	0.86	4.24	0.79	27.09**	0.140

Note: $^{**}p < 0.01$.

4.4. Cross-Cultural Differences

Table 6 presents the mean and standard deviation values of variables across countries. Mean values of teacher-student relationships accompanied by conflict, and those of science learning (Science self-concept, science liking, and ease of learning science) were higher among Japanese students than Thai students. There were significant differences in science self-concept, science liking, and ease of learning science between these two countries, and the effect size was large. In science learning, Japanese students endorsed science self-concept, science liking, and ease of learning science more than Thai students. There was a significant, conflicting teacher-student relationship, and the effect size was medium. Japanese students have more conflicts with teachers than Thai students. The details are described as follows.

Group comparisons between the Japanese and Thai samples revealed several notable cross-cultural differences in both relationship factors and motivational outcomes. The MANOVA results (followed by univariate ANOVAs) indicated that there was no significant difference in perceived teacher-student closeness or in teacher negative expectations between the two countries ($p > 0.05$ in each case). However, teacher-student conflict was significantly higher in the Japanese sample than in the Thai sample ($F = 11.06$, $p < 0.01$), implying that Japanese children

experienced more frequent or intense conflict with teachers on average. In terms of science motivation, Japanese students scored significantly higher than Thai students on all three indicators: science self-concept ($F = 47.47$, $p < 0.01$), science liking ($F = 35.06$, $p < 0.01$), and perceived ease of learning science ($F = 27.09$, $p < 0.01$). These differences showed that the Japanese children felt more confident and interested in science and thought learning science was easier than for Thai students.

4.5. Cross-Cultural Comparison of Variables (ANOVA Results)

An analysis of variance (Table 6) was conducted to compare six key variables between students in Thailand and Japan. Three of these variables represented aspects of the teacher-student relationships (Closeness, negative expectations, and conflict), while the remaining three reflected science learning motivation (science self-concept, liking for science, and ease of learning science). For closeness, no significant difference was found between the two groups ($F = 1.12$, $p > 0.05$). This suggests that students in both countries perceive a similar level of warmth and support from their teachers. Likewise, negative expectations did not differ significantly between the groups ($F = 0.50$, $p > 0.05$). However, for conflict, Japanese students reported a significantly higher level of conflict than Thai students, indicating relatively greater relational tension in Japanese classrooms ($F = 11.06$, $p < 0.01$). In terms of science learning motivation, Japanese students significantly outperformed Thai students on all indicators. Specifically, Japanese students showed higher levels of science self-concept ($F = 47.47$, $p < 0.01$), liking for science ($F = 35.06$, $p < 0.01$), and ease of learning science ($F = 27.09$, $p < 0.01$). These results suggest a reciprocal influence between educational culture and the relational dynamics within classrooms on students' learning motivation. In Japan, despite higher relational tension and a stronger sense of hierarchy, emphasis on academic achievement may enhance students' self-concept and perception of ease of learning. In contrast, while Thai classrooms exhibit relatively less relational tension, the lower pressure for academic achievement may result in reduced motivation for science learning. Overall, these findings highlight the importance of adopting educational approaches that balance emotional security with positive teacher-student relationships to suit the cultural context of each country. This study highlights the significant impact of teacher-student relationships on young children's motivation to learn science. It emphasizes the importance of emotional closeness, reduced conflict, and minimized negative expectations in classroom environments.

The findings reveal that a strong emotional bond between teachers and students correlates positively with children's science self-concept, science liking, and perception of ease of learning. Notably, cultural differences between Japan and Thailand suggest the need for culturally responsive teaching practices, where educators should adapt their relational strategies to suit local social norms and emotional expressions. Drawing on data from 169 preschool and early-primary pupils, 108 in Japan and 61 in Thailand, we confirmed, using the corrected statistics in (Tables 1-6), the pivotal role of teacher-student relationships in shaping early science motivation. Measurement reliability (Table 1) was strong, with Cronbach's α ranging from 0.78 to 0.91 for teacher-student relationships subscales and 0.94 to 0.95 for motivation indicators, ensuring internal consistency. Variable intercorrelations (Table 2) showed significant links ($r = 0.250$ -0.904): closeness related positively to all motivation measures, whereas negative expectations and conflict related negatively. Hierarchical regression analyses (Tables 3-5) revealed that: Science self-concept ($R^2 = 0.357$) was predicted by country ($\beta = 0.523$, $p < 0.01$), closeness ($\beta = 0.209$, $p < 0.01$), and conflict ($\beta = -0.181$, $p < 0.05$). Science liking ($R^2 = 0.403$) was driven by country ($\beta = 0.476$, $p < 0.01$), closeness ($\beta = 0.262$, $p < 0.01$), negative expectations ($\beta = -0.192$, $p < 0.01$), and conflict ($\beta = -0.209$, $p < 0.01$). Perceived ease of learning ($R^2 = 0.380$) followed a similar pattern with country ($\beta = 0.421$, $p < 0.01$), closeness ($\beta = 0.232$, $p < 0.01$), negative expectations ($\beta = -0.253$, $p < 0.01$), and conflict ($\beta = -0.194$, $p < 0.05$). Cross-cultural contrasts (Table 6), ANOVA showed Japanese children outperforming Thai students in self-concept ($F = 47.47$), science liking ($F = 35.06$), and ease ($F = 27.09$); conflict was also higher in Japan ($F = 11.06$), whereas closeness and negative expectations did not differ significantly.

Based on the results, it is useful to reflect on Japan's education system. Traditionally, Japanese education has typically involved group instruction, requiring students to follow group discipline and cooperate with peers. Students

would attend school and participate in clubs, sports, or cultural activities after school. After club activities, students would attend cram schools and review and prepare for classwork. They prefer to have perfect scores on tests and obtain numerous national qualifications, which means securing a job at a major company is almost surely guaranteed. Many Japanese students were educated with a focus on avoiding failure, and being pressured to meet parental expectations meant mastering the basics and achieving perfection in learning. This can lead to a tendency to prioritize a sense of belonging to a group and the recognition of others over intrinsic motivation, potentially leading to stronger extrinsic motivation.

Many people believe that their efforts hold value, which potentially enhances their sustained motivation. In contrast, Thailand is a culture that values hierarchy and respect for teachers. It is common for children to spend their school days in a way that requires them to greet teachers politely. Recognition and instructions from teachers may be significant motivating factors. Furthermore, there is a tendency to value harmony over competition, and we believe that intrinsic interest and enjoyment may be more likely to influence learning motivation. However, it should be noted that the sample sizes were slightly different, which may influence these cross-national comparisons.

The results of the study can provide practical implications for early childhood education policy and teacher training programs. Educational systems should prioritize the fostering of emotionally supportive relationships in the curricula to develop teachers and in the daily teaching practices of teachers. Furthermore, the study underscores the necessity of early interventions that focus not only on academic content but also on the emotional and relational dimensions of classroom learning. Future research should extend these findings by investigating the longitudinal effects of teacher-student relationship quality on long-term academic outcomes, including in science and other STEM domains. Additionally, exploring structured intervention programs across diverse cultural contexts may offer insights into scalable strategies for improving young learners' motivation and engagement through relational support.

5. DISCUSSION

The present study provides clear evidence that the quality of teacher-student relationships is closely linked to young children's motivation in learning science. Across Japan and Thailand samples, children who enjoyed close, supportive relationships with their teachers demonstrated higher science self-concept, greater liking for science, and a stronger sense that science is easy to learn. In contrast, children who experienced conflict or strained relationships or sensed negative expectations from their teachers tended to have lower confidence and interest in science. These patterns are consistent with previous research, which shows that positive teacher-child interactions foster students' emotional security and enthusiasm for learning, whereas conflict and negativity can dampen a child's academic self-concept and engagement (Roorda et al., 2011). According to self-determination theory, supportive teacher-student relationships provide a sense of relatedness, helping children develop their intrinsic motivation to explore and learn in domains like science.

The findings also reveal intriguing cross-cultural differences. Japanese students reported more teacher-student conflict on average than Thai students. The Japanese group showed higher motivation across all science measures. One interpretation may be that Japan's early education system places a stronger emphasis on academic achievement and science enrichment, which may enhance children's science self-concepts and enthusiasm, even in environments with stricter or more formal teaching styles. In contrast to Japan, Thailand tends to be more relaxed in early childhood education and involves less teacher-child conflict. However, this may coincide with a lower emphasis on science, leading to lower science motivation among preschoolers. These explanations highlight the importance of a country's educational culture and students' motivation in the classroom. The data indicate that positive teacher-student relationships benefit children's motivation in both cultures, even if baseline levels of motivation differ. This underscores that fostering warm, low-conflict relationships in the classroom is valuable, but it may need to be adapted to each cultural context. In practice, teacher training programs should emphasize the development of educators' socio-

emotional skills and teacher-student relationship-building practices. Curricula might integrate activities that strengthen teacher-child relationships, such as interactive science explorations or play-based learning. Educational systems, particularly in multicultural or international school settings, should consider cultural differences when applying these approaches. To prioritize the emotional quality of teacher-student relationships, educators and policymakers can support children's curiosity and confidence in science, laying a strong foundation for lifelong engagement in STEM learning.

Despite these contributions, the study has several limitations. First, the imbalance in sample size and age composition between the two country groups (the Thai sample is smaller than Japan) means cross-cultural comparisons should be interpreted cautiously. Second, the reliance on questionnaires and rating scales introduces potential biases; for example, teachers' reports may reflect personal expectations. Third, the cross-sectional design captures a snapshot in time, preventing causal inferences. Future research should employ longitudinal designs and intervention studies to track and enhance the relationship between teacher-student interactions and science motivation (Chan, Maneewan, & Koul, 2023a). Expanding the cultural scope and investigating potential mediating or moderating factors (e.g., emotion regulation, teaching style) would further enrich our understanding.

6. CONCLUSIONS

The tables presented in this study (Tables 1-6) provide empirical evidence for teacher-student relationships and motivation to learn science in early education. The analysis offers actionable insights that can inform teacher training, curriculum design, and international policy development in early STEM education. The findings have practical implications for early childhood educators, particularly in multicultural and international educational contexts, where building emotionally supportive teacher-student relationships can enhance learning outcomes and foster lifelong interest in science. Early childhood marks a critical developmental period for foundational attitudes toward learning and self-concept. At this stage, children's emotional and cognitive orientations toward abstract and systematic domains such as science are strongly influenced by the quality of their relationships with teachers. This study targeted 169 children aged 4 to 8 years from Japan and Thailand to investigate the associations between three motivational indicators, science self-concept, science liking, and perceived ease of learning science, and three teacher-student relationship dimensions: closeness, negative expectations, and conflict. Data were collected through structured questionnaires and analyzed statistically using hierarchical multiple regression and multivariate analysis of variance (MANOVA).

The results revealed that teacher-student closeness had a strong positive influence on all three motivational indicators, whereas conflict and negative expectations significantly reduced children's motivation to learn science. Furthermore, Japanese students scored significantly higher than Thai students on all motivational measures, suggesting that cultural and educational differences play a critical role in shaping science learning motivation. Building on these findings, the present study emphasizes teacher-student relationships fostering young children's science motivation. Positive and supportive interactions are associated with higher self-concept, greater interest, and a stronger sense of ease in learning science. Although cultural differences exist, the benefits of nurturing warm, less conflict in teacher-student interactions are common to all. These results underscore the importance of integrating socio-emotional skill development into teacher training, designing classroom activities that strengthen teacher-child relationships, and tailoring strategies to cultural and educational contexts.

The main empirical findings of this study were that teacher-student intimacy had a positive effect on all motivational indicators, including science self-concept, liking for science, and ease of learning science, while teacher-student conflict and negative expectations significantly reduced children's science learning motivation. Japanese children scored higher on the motivation indicators than Thai children, suggesting that cultural and educational backgrounds influence science learning motivation.

Next, turning to educational implications, in the education of children in early childhood and early elementary

school, building a warm and supportive teacher-student relationship is important for enhancing learning motivation. Furthermore, it can be said that emphasizing the development of social-emotional skills in teacher training and designing classroom activities to strengthen relationships with students are effective. It was shown that incorporating teaching strategies appropriate to cultural and educational contexts can effectively promote science learning motivation across cultures.

Finally, in terms of future research directions, one study will be an intervention study to verify the effect of a relationship-strengthening program on learning motivation, as longitudinal studies may be able to clarify the causal relationship between teacher-student relationships and science learning motivation, which may lead to changes in teacher-student relationships. Another will be an examination of mediating and moderating factors such as cross-cultural comparisons and teaching styles, to gain a deeper understanding of the mechanisms underlying the formation of science learning motivation in early childhood.

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Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
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