



## **THE EFFECT OF THE STEM APPROACH THROUGH DIFFERENTIAL LEARNING ON EMOTIONAL ABILITIES OF CHILDREN AGED 5–6 YEARS QUASI-EXPERIMENTAL STUDY**

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### ***Abstract***

*This study aims to analyze the influence of implementing a STEM approach through learning differentiation on children's emotional abilities aged 5–6 years. Research uses a quantitative, quasi-experimental, nonequivalent control-group design. Subjects, 20 children in total, were divided into experimental and control groups. Data collected through observation and the structured use of the instrument to assess emotional ability, including four aspects: introduction to emotions, self-control, empathy, and expression of positive emotions. Data analysis was carried out using paired t-test, independent t-test, and gain score analysis. Research results show that both groups demonstrate significant emotional ability ( $p < 0.05$ ), and the improvement in the experimental group is greater than in the control group. The average posttest score in the experimental group was 72.3, while the average score in the control group was 55.0. The effect size value (Cohen's  $d$ ) of 4.91 indicates that the intervention has a very strong influence. Findings show that learning STEM-based skills through a differentiation approach is effective in developing children's abilities at an early age. Approach: This provides experience, challenging, collaborative, and adaptive learning, thereby supporting optimal development of regulation, emotions, and empathy in children.*

**Keywords:** *STEM; differentiated learning; emotional abilities; early childhood; Quasi-experiment.*

### **INTRODUCTION**

The development of a child aged 0–6 years is a very decisive stage because at this time the child experiences rapid growth in cognitive, language, motor, social, and emotional domains. In context education, children's age, ability, and emotional needs are understood operationally, so they can be observed, measured, and developed through activity-based study. In this study, emotional ability is defined as the ability of children to recognize



their own emotions, control their emotional responses, show empathy, and express positive emotions in social situations. The fourth aspect is important because it relates to children's readiness to engage in learning, build connections with friends, and adapt to the demands of the school environment. Several studies show that social-emotional, literacy, and numeracy moments entering formal school are predictors of academic achievement at the next stage, even after controlling for children, families, and context (Carpendale et al., 2025). In addition, the ability management self also reported contributing in a way independent of achievements on future days. Findings: This shows that emotional ability in children at an early age is not just an aspect of support but also part of children's readiness.

In this study, emotional ability was measured through four main areas: introverted emotions, self-control, empathy, and positive emotional expression. With the formulation of clear indicators, capabilities, and emotional No placed as a draft general, but as construct developments that can be observed during the child follow-up activity study. Affirmation. This is important because, in practice, aspects of early childhood education focused on social-emotional learning are often positioned as outcomes of activity-based play or learning in general, rather than as explicitly designed achievements within daily activities (Wulandari et al., 2020). As a result, children involved in the activity learn, but do not always receive targeted stimulation to recognize emotions, calm themselves when frustrated, respond to friends appropriately, or express positive emotions adaptively.

Conditions are relevant in the context of Early Childhood Education (PAUD) learning in Indonesia in many situations. Still more emphasis is placed on cognitive aspects early, such as introductions, numbers, and basic academic skills, rather than on the systematic development of emotional abilities. In fact, social-emotional ability in early childhood school is closely related to quality interactions with children, involvement in learning, and self-adaptation to the formal environment (Carpendale et al., 2025). On the other hand, children learn most effectively through direct experience that allows them to explore, try, fail, improve, and interact with other people. Therefore, it is necessary to design learning that is not only active and meaningful but also gives children room to practice regulating emotions and empathy throughout the learning process.

One potential approach to fulfilling the need is STEM (*Science, Technology, Engineering, and Mathematics*). In early childhood education, STEM is not solely understood as an introduction to scientific concepts or technology, but as an approach to learning that encourages children to investigate, try various solutions, work on the same, and reflect on the results of their activities (Johnson, Ed.S., 2024). STEM approach at an early age allows children to explore phenomena, natural or technical, through active, contextual, and project-based activities that are simple, so that children not only accept information, but also experience the learning process in a direct way (Johnson, Ed.S., 2024; Made et al., 2025). Numerous studies also show that STEM integration in education at an early age develops children's potential for non-academic abilities, such as collaboration, creativity, and resilience, and helps them face challenges in learning (Revák et al., 2024; Audi et al., 2020). However, in order for STEM's contribution to emotional ability, it does not stop at claiming a general, necessary, formulated mechanism, but is more psychopedagogical and explicit. In this study, the relationship between STEM and emotional abilities is understood through a number of paths. First, the challenge task in

STEM activities places children in situations that require *problem-solving*, persistence, self-control, and tolerance of failure. Second, collaboration in finishing a project is simply an open room for a child. to listen, wait for their turn, help friends, and show empathy. Third, reflection on results helps the child recognize feelings that arise during the process of trying, succeeding, or failing. Fourth, teacher support during the activity provides emotional and pedagogical support, enabling children to interpret the experience positively (Putri et al., 2021). Through this mechanism, STEM not only functions as an approach to cognitive learning but also as a context for learning that supports the development of emotional intelligence, self-control, empathy, and positive emotional expression (Deris et al., 2024; Huda et al., 2024). In other words, STEM activities provide experiential learning that demands experience, regulation, emotions, social interactions, and the courage to try again. Thus, the effective application of STEM to children at an early age depends very much on how the study is designed to align with the needs of child development. At this point, learning about differentiation becomes important.

Learning differentiation is a customized approach experience. Study with readiness, interest, and profile. Study child (Reis & Renzulli, 2018; Astria et al., 2023; Aprima & Sari, 2022). In this context, differentiation is understood in a general way, but operationalized through a number of components, namely process differentiation, role learning, and environment learning. Process differentiation is carried out with a given variation method; children follow STEM activities, for example, through observation, experiment, live demonstrations, discussion groups, small groups, or mentoring in a gradual manner. Differentiation role: The study conducted assigns different tasks in accordance with children's readiness and interest, such as a child who focuses on observing, someone who helps assemble tools, and those who deliver results (Naibaho, 2023). Differentiation environment: Study done in an arranged atmosphere, learning that provides a sense of security, support, and equal opportunity for every child. For involved. Components. This was chosen because it is most appropriate for children aged 5–6 years and is most likely implemented in a way consistent with activity class (Perry, 2022). In the affirmation component differentiation, it is important that the implementation treatment can be replicated and evaluated. In this study, the implementation differentiation reflected in the adjustment activity with readiness children, the division of flexible roles during the activity, the provision of appropriate teacher support to children, and a chance for all children to be involved, in accordance with their respective abilities (Huda et al., 2024). Thus, learning differentiation not only functions as a strategy for increasing participation but also as conditions that allow children to feel acceptable, capable, and safe in an emotional way during follow-up STEM activities. In the context of PAUD at this developmental level, children are very diverse; adjustments like this are important. It is important that the challenge study not cause excessive pressure but rather become a means for building trust in oneself, self-empathy, and emotional regulation (Deris et al., 2024; Naibaho, 2023).

A number of studies previously discussed STEM and differentiation in separate ways. STEM integration in PAUD is reported to contribute to engagement, learning, creativity, and the ability to work together, whereas learning differentiation is viewed as a responsive approach to the diversity needs of children (Revák et al., 2024; Perry, 2022). Some studies also show that collaborative and exploratory play can strengthen emotional regulation, empathy, and trust in children (Wulandari et al., 2020; Putri et al., 2021). However,

studies that specifically focus on connecting the implementation of the STEM approach through learning differentiation with the emotional needs of young children are still relatively limited, especially in the Indonesian context. Limitations: This shows there is room for testing. How design that combines STEM learning activities, challenges, tasks, equal reflection, and differentiated teacher support can be influential in a child's emotional development.

Based on the description, research was conducted to analyze the influence of implementing a STEM approach through learning differentiation on the emotional states of children aged 5–6 years. Research. This is expected not only to provide empirical evidence of the influence of treatment on introducing emotions, self-control, empathy, and expressing positive emotions, but also to strengthen theoretical contributions that design active, collaborative, challenging, and responsive learning to help children develop social-emotional skills in early childhood education.

## METHODOLOGY

This study uses a quantitative quasi-experimental nonequivalent control group design to analyze the influence of the STEM approach, through learning differentiation, on children's emotional abilities aged 5–6 years. Research was conducted at the Pembina Agropolitan Kindergarten, Toto Selatan Village, Kabila District, Bone Bolango Regency. Subject study involving 20 children (5–6 years old), divided into an experimental group and a control group. The selection was purposive, based on the inclusion criteria: children registered and active at school, aged 5–6 years, who participated in the learning activity during the research, and who had complete pretest and posttest data. Children who do not follow all stages of study or have observation data. No complete issues from the analysis.

Emotional ability in study. This is defined operationally as the ability of a child to recognize emotions, control themselves, show empathy, and express positive emotions during learning activities. Instrument study in the form of sheet observation, consisting of over 20 items, with a division of each aspect into 5 points: introduction, emotions, control self, empathy, and expression of emotions. Assessment uses a scale of 1–4: 1 = not yet developing, 2 = starting to develop, 3 = developing in accordance with expectations, and 4 = developing very well. The arrangement instrument refers to the framework of emotional and social adjustment with the development of social-emotional skills in early childhood. Validity of the content instrument is determined through *expert judgment* by experts in early childhood education. To evaluate the suitability of grains using the indicator of an emotional child aged 5–6 years. Review focused on relevance indicators, clarity of editorial, and suitability of grains with characteristics development in early childhood. Based on input from experts, some grains improved aspects of editorial and clarity observed behavior before the instrument was used in the research. The reliability instrument used is **Cronbach's Alpha**. Data collected through pretest, observation during treatment, and posttest. The group experiment receives STEM-based learning through differentiation, whereas the group control follows conventional learning. To reduce observation bias, assessments are conducted using guidelines that ensure the same observation in each session. Data were analyzed using paired t-tests, independent t-tests, gain scores, and normality tests, with the score used as the baseline for each group.

## RESULTS AND DISCUSSION

### A. Results

Study: This study analyzes the influence of implementing a STEM approach through learning differentiation for children with emotional needs in early childhood at the Pembina Agropolitan Kindergarten, South Toto Village, Kabila District, Bone Bolango Regency. The subject study consists of 20 children, 5–6 years old, divided into two groups: 10 in the experimental group and 10 in the control group. The experimental group learns STEM-based learning through differentiation, whereas the control group follows conventional instruction.

#### 1. Statistics Descriptive

**Table 1. Statistics Descriptive Ability Child Emotional**

Group	Mean Pre	Elementary School Preschool	Mean Post	SD Post	Gain	SD Gain	
Experiment	10	45.5	3.35	72.3	3.20	26.8	3.05
Control	10	44.3	2.87	55.0	3.83	10.7	2.06

The descriptive analysis results show that the average pretest score for the experimental group is 45.5, and for the control group, it is 44.3. This shows that the second group owns a condition relatively early. After treatment, the average posttest score in the experimental group increased to 72.3, while the control group increased to 55.0. Increase scores in the groups experiment more than in the control group, with an average gain of 26.8 in the control group. experiment and 10.7 in the control group.

#### 2. Normality Test

**Table 2. Results of Normality Test (Shapiro-Wilk)**

Data	Statistics	Sig. (p)	Information
Experiment Pretest	0.965	0.840	Normal
Posttest Experiment	0.900	0.217	Normal
Pretest Control	0.922	0.376	Normal
Posttest Control	0.931	0.458	Normal

Normality test results show that all data are normally distributed ( $p > 0.05$ ), so analysis parametric can be used.

#### 3. Paired t-test

**Paired t-Test Results**

Group	Mean Pre	Mean Post	t- count	Sig.
Experiment	45.5	72.3	17.8	0.000

<b>Control</b>	44.3	55.0	13.5	0.000
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Paired t-test results indicate a significant difference between pretest and posttest scores in both groups. In the group experiment, the obtained t value = 17.8 with  $p < 0.05$ , whereas in the group control, the obtained t value = 13.5 with  $p < 0.05$ . This result shows that the second group improved in emotional ability, but the improvement in the experimental group was much greater than in the control group.

**4. Independent t-Test Results**

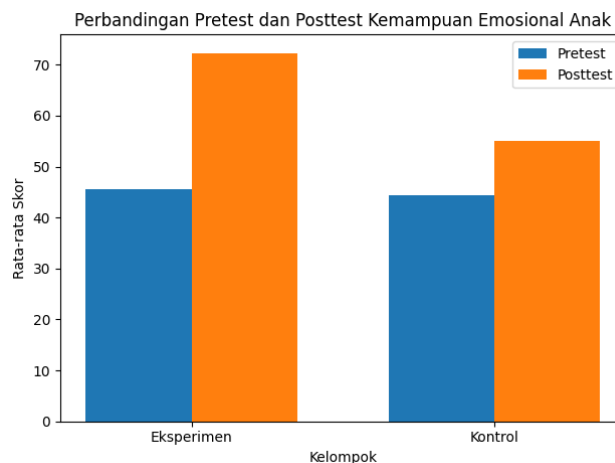
*Independent t-Test Results*

Group	Mean	Elementary School	t- count	Sig.
<b>Experiment</b>	72.3	3.20		
<b>Control</b>	55.0	3.83	7.2	0.000

For known differences between groups, an independent t-test was performed to assess the posttest. Analysis results show a t-value of 7.2, with  $p < 0.05$ . This shows that there is a significant difference between emotionally able children in the experimental groups and the control groups after treatment was given. The group experiment had a higher score than the group control.

**5. Comparison of Pretest and Post-test Averages**

**Figure 1. Comparison of Average Pretest and Posttest Ability Scores of Child Emotional**

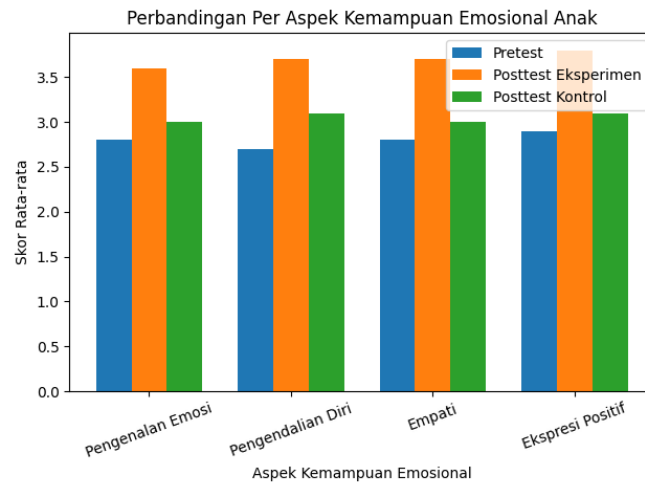


The chart shows that the second group improved in emotional ability, but the improvement in the experimental group was greater than in the control group. This indicates that implementing a STEM approach through learning differentiation has a greater impact on children's emotional development.

**6. Comparison of Children's Emotional-Based Aspect**

Aspect analysis was used descriptively to strengthen the overall interpretation. This is shown in Figure 2.

**Figure 2. Comparison of Children's Emotional-Based Aspect**



The chart shows that improvement in emotional ability occurs across all aspects, namely the introduction of emotions, self-control, empathy, and positive emotional expression. The most prominent improvement was seen in the control self and empathy aspects of the group's experiment compared to the group control. This indicates that STEM-based activity learning through differentiation makes a significant contribution to the development of emotional regulation and social interactions in children.

## B. Discussion

Research result. This strengthens the theory that the STEM approach, if implemented with the principle of learning differentiation, can offer a deeper meaning in the educational process for children. Children not only study simple science concepts but also learn to manage emotions, work together, and appreciate the different learning processes of each individual. Improvement. This is exemplified through the ability of children to manage anger more effectively and use the technique of soothing *self-talk*, such as "inhale, exhale" (Luo et al., 2025). During activity experiments, children in STEM groups are more expressive, enthusiastic, and involved in every activity. They are capable of working together, building a simple tool, discussing the results of experiments, and positively overcoming failure. This process helps them recognize personal emotions, manage frustration, and grow empathy for friends. Playing with peers in the environment, education, and upbringing of children in early childhood education (PAUD) provides children with a valuable chance to navigate the social world and establish good friendships (Coelho et al., 2017; Koivula & Hännikäinen, 2017). All children need fundamental skills to feel their own for forming and maintaining positive and meaningful social relationships (Salo et al., 2026). For example, awareness of self allows children to recognize their emotions, feel alone, and understand how emotions influence their interactions with other people. Likewise, awareness, social empathy, and the ability to understand other people's perspectives and feelings can reduce the likelihood that children will engage in bullying behavior (Luo et al., 2025). Research has identified emotional ability as a framework encompassing the development of knowledge, self-independence, awareness of social situations, interpersonal and decision-making skills, and responsible decision-making (Klinge et al., 2025). Skills are important for the development of personal and social skills in children; these skills allow them to understand and organize their emotions, form and maintain healthy relationships, and make responsible decisions.

Collaborative STEM activities can increase regulation, emotions, and abilities in social children through active, mutual interaction and support (Wulandari et al., 2020). As well as STEM activity being exploratory, it contributes to the formation of trust in self-emotionally in children. Social-emotional skills can help children engage with others, creating a strong foundation for practicing skills that can be carried forward (Kuutti et al., 2021; Stangeland, 2017). Skills can also help build positive connections with friends (Coelho et al., 2017) and thus fulfill the need for a strong sense of desire, knowledge, and a strong attitude of enthusiasm, which are prominent characteristics in children aged 5-6 years. Children have a strong sense of adventure (*adventurousness*). They will carefully notice, discuss, and ask questions about everything they see or hear. Children need to be involved in various activities, good for developing muscles, small and large (Ningsih et al., 2023).

Temporarily, learning differentiation gives children the opportunity to study according to their interests and abilities, so that every child feels appreciated and motivated. Children feel useful material studied through learning strategies that present learning in accordance with learning styles. Adjustment will make it easier for participants to convey new or difficult information (Kurniati et al., 2019). Teachers can modify and adapt teaching materials or plan how participants will learn something through topic learning, adjusting for readiness, liking, or method. A study is best for children. According to Azizah et al. (2024), the learning strategy is differentiated by the method participants use to teach them to interpret or understand something material through gradual activity, meaning each participant will build a common understanding. However, there are a number of challenges that differ. The meaning of matter is that each participant will educate themselves and engage in an activity to gain knowledge, understanding, and skills through different methods. Tomlinson (2021) confirms that differentiation not only improves academic outcomes but also strengthens affective aspects, including sensitivity and emotional balance. The results of the study confirm that implementing the STEM approach through learning differentiation not only increases children's ability to think scientifically but also influences the development of emotional abilities holistically. Findings. This supports the views of Goleman (2021) and Yoon & Park (2023) that challenging and collaborative learning can help regulate emotions, foster empathy, and cultivate a sense of responsibility, thereby addressing social issues from an early age. In activities, play, and bonding, positive interactions and connections with friends are very important for children. To fulfill their needs, they will have a sense of belonging in education and upbringing, in early childhood (PAUD).

## CONCLUSION

Based on the results of the data analysis, it can be concluded that the implementation of the STEM approach through learning differentiation has a positive and significant influence on the emotional abilities of children aged 5–6 years. This is indicated by an increased emotional ability score in the group experiment, from an average of 45.5 to 72.3, which is higher than the group with increased control, from 44.3 to 55.0. Statistical test results show a significant difference ( $p < 0.05$ ) and a very large effect size value, indicating that the intervention's impact on the development of emotionally children is strong. Improvement in emotional abilities, especially in self-control and empathy, which develop through children's involvement in exploratory, collaborative, and challenging STEM activities. Learning differentiation plays a role in adapting the level of difficulty

and in forming activities with readiness children, so as to create a safe and supportive learning environment for optimal expression of emotions. In a way, a practical results study. This implies that PAUD teachers can integrate a STEM approach through learning differentiation by designing simple, activity-based projects for work groups, as well as reflection experiences. This study aims to foster children's emotional development. However, the implementation approach needs to consider availability, including learning, teacher readiness, and the ratio of mentoring children in class. This study's own limitations include a small sample size and a limited research location to one institution, so the results cannot yet be generalized to a wider area. In addition, other factors, such as teacher characteristics and the effects of novelty, can also influence research results. Therefore, research furthermore recommended involving a larger sample size, carried out on various contexts of early childhood education institutions, as well as studying more deeply the development of each emotional ability aspect longitudinally to get a clearer picture.

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