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Emotional Changes In Students' Learning In Chemistry Classes Through The Stem Approach

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Abstract

This study aims to describe changes in students' emotional learning and engagement in chemistry instruction on the topic of chemical bonding through the STEM approach at State High School 1 in Gorontalo City, using a descriptive quantitative approach. The study subjects consisted of 60 students, comprising 30 students in the experimental class (STEM learning) and 30 students in the control class (conventional learning), selected through purposive sampling. The instrument used was a five-category Likert scale questionnaire covering aspects of emotional learning (enjoyment, pride, anger, anxiety, shame, despair, and boredom) as well as student engagement (participation, motivation, and interaction). Data were collected after the lesson and analyzed descriptively using mean values and percentages. The results of the study indicate that the experimental class exhibited more positive emotional responses to learning and higher levels of engagement compared to the control class, suggesting that the STEM approach is effective in improving the quality of chemistry learning

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Keywords: STEM Approach; Emotional Learning; Student Engagement; Chemistry Education.

INTRODUCTION

Chemistry education is a field of study characterized by complexity, particularly in the area of chemical bonding, which requires conceptual understanding and abstract thinking skills. Many students struggle to grasp these concepts because they must simultaneously connect macroscopic, microscopic, and symbolic representations. This situation not only impacts cognitive aspects but also elicits a variety of emotional responses during the learning process (Talanquer, 2020; Becker et al., 2022).

Emotions in learning are a critical factor influencing student learning success. Positive emotions such as joy and pride can enhance motivation, attention, and student engagement in learning. Conversely, negative emotions such as anxiety, anger, boredom, and despair can hinder the thinking process and reduce students' interest in learning (Pekrun & Linnenbrink-Garcia, 2021; Loderer et al., 2020). Therefore, it is important to understand students' emotional states during the learning process.

In addition to emotional aspects, student engagement is also a key indicator of learning success. Student engagement encompasses active participation in learning activities, motivation to learn, and social interaction in the classroom. High levels of engagement indicate that students are not merely physically present but are also cognitively and emotionally engaged in the learning process (Fredricks et al., 2022). Thus, analyzing student engagement is crucial for assessing the quality of the learning process.

However, chemistry instruction in schools remains dominated by conventional, teacher-centered approaches. Such teaching tends to offer few opportunities for students to participate actively, often leading to boredom and low motivation to learn (OECD, 2021; Schindler et al., 2021). This situation highlights the need for educational innovations capable of enhancing students' learning experiences in a more meaningful way.

One approach that can be utilized is the STEM (Science, Technology, Engineering, and Mathematics) approach. This approach integrates various disciplines and emphasizes problem-based learning and collaboration. Through the STEM approach, students are encouraged to actively explore concepts, engage in discussions, and solve problems relevant to real-life situations. This has the potential to create more engaging learning experiences and enhance positive emotions and student engagement (Margot & Kettler, 2020; Thibaut et al., 2021; Nugroho

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et al., 2023).

However, studies specifically describing students' emotional states and engagement in STEM-based chemistry learning remain limited, particularly regarding chemical bonding. Most research emphasizes cognitive learning outcomes, while emotional aspects and engagement have not been extensively explored descriptively as part of learning evaluation.

Based on this, this study aims to describe students' emotional states and engagement in chemistry learning on the topic of chemical bonding through both the STEM approach and conventional teaching. Using a quantitative descriptive approach, this study is expected to provide a comprehensive overview of students' emotional profiles and engagement as a foundation for developing more effective, student-centered chemistry learning strategies.

RESEARCH METHODOLOGY

This study employed a descriptive quantitative approach aimed at describing changes in students' emotional engagement and learning in chemistry lessons on chemical bonding using the STEM approach. The study subjects consisted of two high school classes: (1) an experimental class of 30 students who received STEM-based instruction; and (2) a control class of 30 students who received conventional instruction. Sampling was conducted using purposive sampling, taking into account the equivalence of students' initial abilities.

The instrument used was a Likert-scale questionnaire with five rating categories: Strongly Agree (SS) = 5, Agree (S) = 4, Somewhat Agree (KS) = 3, Disagree (TS) = 2, and Strongly Disagree (STS) = 1. The research instruments consisted of a learning emotion questionnaire, covering seven aspects: enjoyment, pride, anger, anxiety, shame, despair, and boredom. Additionally, a student engagement questionnaire, covering three aspects: active participation, learning motivation, and classroom interaction.

The study was conducted in several stages, including: the preparation stage, which involved developing the instruments and instructional materials; the implementation stage, which involved delivering STEM instruction to the experimental class and conventional instruction to the control class; and the data collection stage, which involved distributing the questionnaires to students after instruction concluded.

Data were analyzed using quantitative descriptive techniques by calculating the mean and percentage for each indicator. Scores were interpreted by grouping the results into categories, such as very high, high, moderate, low, and very low. The results of the analysis were then used to describe the differences in learning emotions and student engagement between the

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experimental and control classes.

RESULTS AND DISCUSSION

Changes in students' learning outcomes were analyzed by calculating the difference between posttest and pretest scores on the person measure, which had been calibrated using the Rasch Model. A positive difference indicates an increase, while a negative difference indicates a decrease. To interpret the magnitude of the change more meaningfully, these differences were categorized based on the standard deviation (SD) of the distribution of differences for each group. In Statistical Power Analysis for the Behavioral Sciences, the use of SD-based effect sizes to assess the magnitude of change is discussed, where a change is considered practically significant if it exceeds half to one SD. The standard deviation (SD) of the difference is used as a reference to determine whether the change is significant or not.

Table 1. Definitions of categories of emotional changes in learning based on the difference and standard deviation

Category of Change	Difference Criteria (Posttest – Pretest)	Interpretation of Changes
A significant increase	Difference > SD	Changes exceeding the average variation within the group indicate significant progress
Just another day	0 < Difference ≤ SD	A positive change, but still within the normal range
No change	Difference = 0	There was no change in the emotional learning scores between the pretest and the posttest
Decreasing	-SD ≤ Difference < 0	There has been a decrease, but it remains within the normal range
Decreased significantly	Difference < -SD	The decrease exceeds the average variation within the group,

Based on the data obtained, the standard deviation of the difference for the experimental class was 0.73, while for the control class it was 0.60. To gain a deeper understanding of the dynamics of students' affective changes, the results of the emotional learning measurements were not only compared overall but also categorized based on the magnitude of individual

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changes. This categorization refers to the standard deviation of the difference in each student's score, thereby identifying whether the changes that occurred were significant, moderate, or even negative. This analysis reveals variations in students' responses to the treatment, indicating that not all students experienced changes of the same magnitude. The distribution of emotional learning changes per student in each group is presented in Table 2.

Table 2. Categorization of Changes in the Emotional Level of Learning Among Students in the Experimental and Control Classes

Categorization of Emotional Changes in Learning								
Control Class (SD = 0.60)				Experimental Class (SD = 0.73)				No
Pretest	Post-test	Difference	Category	Pretest	Post-test	Difference	Category	
1.65	1.27	-0.38	Decreased	1.49	2.38	0.89	Significantly increased	1
1.23	0.62	-0.61	Significantly decreased	1.56	2.38	0.82	Significantly increased	2
1.05	0.62	-0.43	Decreased	1.49	2.75	1.26	Significantly increased	3
2.36	1.46	-0.9	Decreased	0.83	1.24	0.41	No significant change	4
1.43	0.3	-1.13	Significantly decreased	0.83	1.71	0.88	Significantly increased	5
1.43	0.49	-0.94	Significantly decreased	1.71	2.04	0.33	No significant change	6
1.05	2.51	1.46	Significantly increased	0.94	2.38	1.44	Significantly increased	7
2.16	0.84	-1.32	Significantly decreased	1.11	2.47	1.36	Significantly increased	8
0.5	2.29	1.79	Significantly	1.56	2.12	0.56	No significant	9

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Categorization of Emotional Changes in Learning								
Control Class (SD = 0.60)				Experimental Class (SD = 0.73)				No
Pretest	Post-test	Difference	Category	Pretest	Post-test	Difference	Category	
			increased				change	
0.84	1.4	-0.56	Decreased	1.29	2.65	1.36	Significantly increased	10
1.8	0.75	-1.05	Significantly decreased	1.49	2.65	1.16	Significantly increased	11
1.89	2.78	0.89	Significantly increased	2.78	3.42	0.64	No significant change	12
0.78	2.4	-1.62	Significantly decreased	1.71	1.79	0.08	No significant change	13
2.16	0.66	-1.5	Significantly decreased	2.13	2.12	-0.01	Decreased	14
0.14	1.4	-1.26	Significantly decreased	2.04	1.79	-0.25	Decreased	15
1.05	1.53	-0.48	Decreased	1.96	1.24	-0.72	Decreased	16
1.43	0.99	-0.44	Decreasing	1.17	2.29	1.12	Significantly increased	17
0.94	0.99	0.05	No change	1.36	2.38	1.02	Significantly increased	18
1.05	1.46	0.41	No change	3.37	1.63	-1.74	Significantly decreased	19
1.72	1.67	-0.05	Decreasing	3.37	1.32	-2.05	Significantly decreased	20
2.25	0.89	-1.36	Significantly	1.87	2.47	0.6	Changed	21

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Categorization of Emotional Changes in Learning								
Control Class (SD = 0.60)				Experimental Class (SD = 0.73)				No
Pretest	Post-test	Difference	Category	Pretest	Post-test	Difference	Category	
			decreasing					
1.43	1.46	0.03	No change	2.78	2.75	-0.03	normally	22
1.36	0.53	-0.83	Significantly decreasing	1.23	1.63	0.4	Decreased	23
1.05	1.1	0.05	No change	1.79	2.04	0.25	Changed	24
1.5	0.45	-1.05	Significantly decreasing	1.36	2.04	0.68	Normally	25
2.16	0.89	-1.27	Significantly decreasing	1.11	2.65	1.54	Changed	26
2.06	0.75	-1.31	Significantly decreasing	2.13	1.87	-0.26	normally	27
1.36	1.46	0.1	No change	1.87	2.21	0.34	Changed	28
1	1.53	0.53	No change	1.96	1.87	-0.09	normally	29
1.72	0.41	-1.31	Significantly decreasing	1.71	4.41	2.7	Significantly increased	30

The skewed distribution of changes between the two groups confirms the effectiveness of the STEM intervention. The majority of students in the experimental class (43.3%) showed a significant improvement, while in the control class, the proportion of students experiencing a decline in academic emotions was 10%. This pattern aligns with the postulates of Control-Value Theory, in which the integration of the STEM approach is believed to provide a greater sense of control and value in learning, thereby triggering and sustaining positive academic emotions and deeper engagement. To facilitate interpretation, the results of this categorization are summarized in percentage form as shown in Table 3.

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Table 3. Categories of changes in the emotional level of learning among students in the experimental and control classes

Change Category	Experimental Class (n=30)	Control Group (n=30)
Significant Increase	13 students (43.3%)	3 students (10%)
Moderate Change	9 students (30%)	6 students (20%)
No Change	0 students (0.72%)	0 students (0%)
Decrease	5 students (16.7%)	8 students (26.7%)
Significant Decrease	3 students (10%)	13 students (43.3%)
Total	30 students	30 students

Table 3 shows that the percentage of students who experienced a significant improvement in emotional learning was significantly higher in the experimental class (43.3%) than in the control class (10%). Conversely, the percentage of students who experienced a significant decrease in emotional learning was higher in the control class (43.3%) than in the experimental class (10%), while those who experienced a decrease in the control class were more numerous (26.7%) compared to the experimental class (16.7%). In the control class, the percentage of students who did not experience any change was 0%, and the same percentage was found in the experimental class. This indicates that the application of the STEM approach is more effective in improving students' emotional learning compared to conventional learning.

CONCLUSION

Based on the research findings and discussion outlined above, the following key conclusions can be drawn: The implementation of the STEM approach results in more positive and meaningful changes in learning emotions compared to conventional learning. An analysis of individual changes using the racking technique within the Rasch Model framework revealed that 43.3% of students in the experimental class experienced a significant increase in learning emotions, far exceeding the control class, which reached only 10%. Conversely, the proportion of students who experienced a significant decrease in learning emotions in the control class was 43.3% higher than in the experimental class, which was only 10%.

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