Achievement emotions of female students in mathematical problem-solving situations

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Abstract. Achievement emotions have an important role in students’ Mathematics learning outcomes. The dynamic of achievement emotions in mathematics learning evaluation is very important to be considered by the teachers so that students’ academic achievement can be improved. This study was conducted to investigate female students’ achievement emotions in mathematical problem-solving situations. The study involved 50 seventh grade female students selected by using purposive sampling technique. The data were collected through achievement emotions questionnaires and mathematical problem-solving ability tests. The data were analyzed using Wilcoxon test and Kendal's Tau correlation test. The findings indicated that mathematical problem-solving situation gave significant small negative effect in decreasing students’ joyful emotion. Moreover, it also gave significant small positive effect in increasing students’ depressed emotion. In addition, there was a significant moderate correlation between mathematical problem-solving ability and students’ joyful emotions after the test. Based on the findings, Mathematics teachers were recommended to take control over the students and improve students’ perceived control and confidence value during Mathematics evaluation so that their emotional condition could be well-controlled. Therefore, they could acquire good achievement and the learning objectives could be attained.

1. Introduction

Achievement emotions, such as anxiety, frustration, and hope, are always involved in student learning activities because they are biological and psychological conditions associated with learning activities like problem-solving and examinations [1,2]. The interaction between students, Mathematics teachers, and Mathematics learning created activities during Mathematics learning process [3-6]. One of Mathematics learning process forms is Mathematics evaluation [7,8]. Thus, Mathematics ability test, such as mathematical problem-solving ability, must involve achievement emotions.

Unexpectedly, students’ achievement emotions, either positive or negative, were varied during Mathematics ability tests depending on the situation like Mathematics ability tests demanding students’ higher order thinking in mathematical problem-solving [9,10]. Students anxiousness before and after Mathematics tests could be caused by students’ anxiety, nervousness, stomach-ache, and hopelessness [1]. Anxiety, nervousness, hopelessness, boredom, and anger caused bad learning result and psychology so that it was very essential to be considered by teachers, especially Mathematics teachers.

Some previous studies on the students’ achievement emotions were more likely to observe and investigate the teaching quality, classroom management, and during the learning processes [11-14]. However, there were limited studies on students’ Mathematics evaluation. Moreover, some studies
regarding students’ achievement emotions during Mathematics evaluation process were conducted but the evaluation was carried out outside of the lesson, in the form of homework and not specific to gender [15-17]. On the other hand, this study investigated students’ achievement emotions during the test of mathematical problem-solving abilities conducted during the lesson and specifically to female students. Female students were chosen as the subject since some previous studies on female emotion indicated that females felt worried, hopeless, bored, and angry more than males in depressed situations [18-20], unhappy and proud with the work they did more than males [21,22]. Moreover, those feeling occurred more in adolescent females than in adult females [23,24]. Therefore, if Mathematics teachers did not put this into account, it will affect female students’ learning motivation and achievement which tend to be lower than male students [15].

This study aimed to investigate the achievement emotions of female students in mathematical problem-solving situations by answering the following questions: 1) is there any effect of mathematical problem-solving situations on female students’ achievement emotion changing? 2) is there any correlation between the mathematical problem-solving ability level and female students’ achievement emotion after taking the test?

2. Methods
2.1 Research design, participants, and procedure
Quantitative method with associative correlation and causal-comparative were employed in this study. This study involved 50 seventh grade female students selected by purposive sampling techniques. This technique was chosen as there was no limitation and it allowed researchers to obtain the most appropriate sample [25-27]. The procedure used in this study was adopted from the previous studies [16]. First, students filled out questionnaires about the achievement emotion for 5 – 10 minutes. Second, students did Mathematics problem-solving tests for 60 minutes. Third, students filled out the questionnaires about the achievement emotion again for 5 – 10 minutes.

2.2 Instruments
The instrument used to measure students achievement emotions experience was adopted from [30]. In this study, the students’ achievement emotions measured before the Mathematics problem-solving test were enjoyment, anxiety, hopelessness, and boredom, while the students’ achievement emotions measured after the test were enjoyment, anxiety, hopelessness, boredom, pride, and anger. These emotional forms of achievement represented pleasant dimension (joyful & proud) and unpleasant dimension (anxious, hopeless, bored, and angry) [28-30]. The instrument used to measure the mathematical problem-solving ability level was a written test consisting of five essay questions about proportion topic adapted from Junior High School National Mathematics Olympiad questions year 2016 – 2019.

2.3 Statistical analysis
Data from the questionnaires were analyzed using Wilcoxon test to identify the effect of mathematical problem-solving situations on students’ achievement emotions. Cohen’s equation is used to measure the effect size of mathematical problem-solving situations on students’ achievement emotions [31]. Therefore, Cohen’s effect size classification was used to interpret the magnitude of mathematical problem-solving situation effect on students’ achievement emotion [32]. The classification of the interpretation of Cohen’s effect size is presented in Table 1.
Table 1. The Cohen’s effect size classification

| Effect Size (ES) | Interpretation  |
|-----------------|-----------------|
| 0.00 ≤ ES < 0.20 | Ignored         |
| 0.20 ≤ ES < 0.50 | Small           |
| 0.50 ≤ ES < 0.80 | Medium          |
| 0.80 ≤ ES < 1.30 | Large           |
| 1.30 ≤ ES       | Very Large      |

On the other hand, the data of mathematical problem-solving test and the questionnaire after the test were analyzed using Kendall’s Tau correlation test to observe the correlation between mathematical problem-solving ability and students’ achievement emotion after the test. Correlation coefficient values obtained from Kendall’s Tau test were transformed into Cohen’s equation to determine the magnitude of the correlation between mathematical problem-solving ability and the students’ achievement emotion after the test [31]. All calculations performed in this statistical analysis were assisted by SPSS, Comprehensive Meta-Analysis (CMA), and Microsoft Excel application.

3. Result and Discussion

3.1 The effect of the mathematical problem-solving situations on students’ achievement emotions

Students’ achievement emotion before and after experiencing mathematical problem-solving situations can be illustrated in Table 2.

Tabel 2. The students’ achievement emotion before & after mathematics problem-solving test

| Category          | Enjoyment | Anxiety | Hopelessness | Boredom |
|-------------------|-----------|---------|--------------|---------|
|                   | T1 (%)    | T2 (%)  | T1 (%)       | T2 (%)  |
| Very joyful       | 5.88      | 11.76   | 15.69        | 7.84    |
| (5)               |           |         |              |         |
| Joyful            | 41.18     | 25.49   | 41.18        | 56.86   |
| (4)               |           |         |              |         |
| Middling          | 35.29     | 27.45   | 33.33        | 23.53   |
| joyful            |           |         |              |         |
| Not joyful        | 13.73     | 23.53   | 7.84         | 7.84    |
| (2)               |           |         |              |         |
| Very not          | 3.92      | 11.76   | 3.92         | 1.96    |
| joyful            |           |         |              |         |
| Modus             | 4         | 3       | 4            | 4       |

Note: T1 (Before mathematics problem-solving test); T2 (After mathematics problem-solving test)

Table 2 shows that mathematical problem-solving situations affected students’ enjoyment, anxiety, hopelessness, and boredom emotion. Students who were joyful before the test changed into quite joyful after the situation. Similarly, students who were initially not hopeless before the situation felt hopeless after the situation. Moreover, students who initially tended to feel not bored with the situation became quite bored after the situation. The result of the non-parametric Wilcoxon paired test is presented in Table 3.
Table 3. Students’ achievement emotion intensity based on emotion type and time

| Criterion                  | Enjoyment | Anxiety | Hopelessness | Boredom |
|----------------------------|-----------|---------|--------------|---------|
| Mean                       | 3.32      | 3.60    | 2.34         | 2.74    |
| Deviation standard         | 0.93      | 0.92    | 0.98         | 1.10    |
| Wilcoxon counting value    | -2.480    | -0.022  | -3.978       | -0.723  |
| Sig (α = 0.05)             | 0.013     | 0.982   | 0.000        | 0.470   |
| Cohen’s effect size (d)    | -0.365    | -0.003  | 0.495        | 0.103   |

Table 3 reveals that mathematical problem-solving situation had a significant effect on the students’ joyful and hopeless emotions. Mathematical problem-solving situation gave a small negative effect (ES = -0.365) on the students’ joyful emotion. Moreover, mathematical problem-solving situation had a small positive effect (ES = 0.495) on the students’ hopeless emotion. These findings were similar with previous studies showing that mathematical problem-solving situation contributed a significant effect on decreasing students’ pleasant achievement emotion and increasing students’ unpleasant achievement emotion [15,16]. However, mathematical problem-solving situation did not affect significantly on students’ anxiety and boredom. Thus, mathematical problem-solving situations had insignificant and minor effect on the students’ anxiety and boredom. The Small effect size, which could be ignored, from the effect of mathematical problem-solving situations on the students’ achievement emotions was supported by previous studies conducted by [33-35].

The changes on students’ emotions from joyful to quite joyful after mathematical problem-solving situation proved that there were negative effects of mathematical problem-solving situations on students’ enjoyment. In addition, students changed their emotion from not hopeless to hopeless after mathematical problem-solving situation. This implied that there was a positive effect of mathematical problem-solving situation on students’ hopeless emotion. The decrease of students’ pleasant achievement emotion and increase of students’ unpleasant achievement emotion were due to the interaction between perceived control and confidence value in predicting the type of achievement emotion experienced by students in mathematical problem-solving situations [1,36,37]. Students who had high perceived control and confidence value would experience positive emotions so that students felt mathematical problem-solving situations were challenging and make them curious to solve them. However, students who had a low perceived control and confidence value would experience negative emotions so that they considered mathematical problem-solving situation was distressful, frustrating, hopeless, confusing, and annoying. Thus, the teacher’s role was essential in preparing and creating a valid and high-quality instrument of mathematical problem-solving test.

3.2 The correlation between mathematical problem-solving ability levels and students’ achievement emotions

The result of the correlation between mathematical problem-solving ability and students’ achievement emotion after the test with Kendal’s Tau correlation test is presented in Table 4.

Table 4. The correlation between mathematical problem-solving ability level and students’ achievement emotion

| Students’ achievement emotion | Mathematical problem-solving ability level | Correlation coefficient (r) | Sig. (α = 0.05) | d-value |
|------------------------------|------------------------------------------|----------------------------|-----------------|---------|
| Enjoyment                    |                                         | 0.270                      | 0.017           | 0.730   |
| Anxiety                      |                                         | -0.167                     | 0.154           | 0.459   |
| Hopelessness                 |                                         | -0.119                     | 0.303           | 0.472   |
| Boredom                      |                                         | -0.173                     | 0.130           | 0.485   |
| Pride                        |                                         | 0.085                      | 0.457           | 0.190   |
| Anger                        |                                         | -0.025                     | 0.825           | 0.140   |

Table 4 demonstrates that mathematical problem-solving ability and students’ enjoyment emotion after the test had a significant correlation with moderate correlation. However, there was no significant
correlation between mathematical problem-solving ability and students’ anxiety, hopelessness, boredom, pride, and anger emotions. The correlation between mathematical problem-solving ability and students’ anxiety, hopelessness, and boredom was low and the correlation between mathematical problem-solving ability and students’ pride and anger could be ignored. These findings were almost similar to Tornare et al who found out that the correlation between students’ anxiety, boredom, pride, and anger and mathematical problem-solving ability did not have a significant correlation, except hopeless emotion [16].

A positive correlation between students’ mathematical problem-solving ability and students’ joyful emotion indicated that students’ high mathematical problem-solving ability led to their high perceived control and confidence value so that they felt more joyful with mathematical problem-solving test given. On the contrary, students with low mathematical problem-solving ability led to students’ low perceived control and confidence value so that they felt more stressful with mathematical problem-solving tests given.

The mediator of students’ metacognitive experiences is also an important factor to be considered in analyzing the correlation between mathematical problem-solving ability and students’ achievement emotion. This is because students’ achievement emotions experience was built by cognitive judgement done by students in mathematical problem-solving situations and not by objective contingencies [38-40]. The findings in other studies indicated that cognitive activation had a positive correlation with students’ joyful emotion and had negative correlation with students’ bored emotion [11]. However, the mediator was not included in this study. Therefore, the insignificant correlation between students’ mathematical problem-solving ability and their achievement emotion could be caused by the absence of students’ metacognitive experiences mediator.

3.3 The implication of achievement emotions in mathematics learning evaluation

The theory of perceived control and confidence value recommended that students’ high perceived control and confidence value during Mathematics evaluation could increase students’ pleasant achievement emotions and decrease students’ unpleasant achievement emotions. Increasing students’ pleasant achievement emotions and decreasing their unpleasant achievement emotions would help students to improve their mathematics learning outcomes because the achievement emotions was related to students motivation which impacted students’ mathematics learning outcomes [13].

The results of this study indicated there were several teachers’ roles to notice the supporting and controlling students’ achievement emotions factors during the evaluation, especially in Mathematics. First, improving students’ perceived control and confidence value by preparing an interesting and qualified evaluation integrated with good quality learning. Second, providing support and motivation to students so that they completed and worked on the task given [41]. However, these tasks should not be too easy and repetitive and complex because too easy, repetitive, and complex tasks would resulted on students’ negative achievement emotions [42]. Further, the tasks given should fulfill the students’ needs, for example authentic tasks that were believed to be able to increase students’ pleasant achievement emotions and decrease students’ unpleasant achievement emotion [13]. Third, giving feedback at the end of learning played an important role in the learning evaluation, because informative feedback could increase students’ pleasant achievement emotions and decrease the students’ unpleasant achievement emotion [43].

4. Conclusion

Mathematical problem-solving situations that affected on the decrease of female students’ pleasant achievement emotions and increase of the unpleasant achievement emotions signified the importance of female students’ achievement emotions for teachers, especially Mathematics teachers during the evaluation. Therefore, the female students’ achievement emotions characteristics which tend to be more anxious, more hopeless, more bored, and angrier than male students in depressed situations and tend to be not joyful and proud to the work they did compared with male students could be minimized by taking several important factors in mathematics learning evaluation. Interesting and excellent mathematics
learning evaluation would bring up high perceived control and confidence value. As a result, students’ pleasant achievement emotions would increase and students’ unpleasant achievement emotions would decrease. Thus, well-controlled students’ achievement emotions during Mathematics evaluation would help students to obtain good Mathematics learning outcomes and corresponded to the learning objectives.

There were still some weaknesses in this study both in data collection techniques and in the absence of mediator. Thus, it is recommended that other researchers conduct studies by using triangulation principles in collecting the data such as employing observation, questionnaires, and depth interviews. Furthermore, researchers should involve the mediator of students' metacognitive experiences in analyzing the effect and the correlation of students’ mathematical problem-solving situation and students’ achievement emotions in the future.

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