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Mathematical Problem-Solving Ability Within The Osborn Model Using The Brainstorming Technique: A Self-Efficacy Perspective

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Abstract

This study aimed to analyze the quality of the Osborn learning model combined with the brainstorming technique regarding students' mathematical problem-solving abilities; the influence of self-efficacy on these abilities within this learning model; and the students' mathematical problem-solving performance based on their self-efficacy levels. A mixed-methods approach with a sequential explanatory design was employed. The study population consisted of eighth-grade students at SMP Pangudi Luhur Domenico Savio Semarang. Research subjects were selected based on self-efficacy levels—categorized as high, medium, and low. Instruments used included a self-efficacy questionnaire, a mathematical problem-solving ability test, and interview guidelines. The results indicate that the Osborn learning model with the brainstorming technique is of high quality and effective; self-efficacy positively influences students' mathematical problem-solving abilities within this model; and regarding performance based on self-efficacy levels: (1) students with high self-efficacy mastered all problem-solving stages excellently; (2) students with medium self-efficacy were able to solve problems but lacked thoroughness during the "review" stage; and (3) students with low self-efficacy were only able to comprehend the problem without successfully completing the solution plan.

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INTRODUCTION

Mathematics is a comprehensive discipline that plays a crucial role in shaping human thought processes and serves as a foundation for the advancement of science and technology. Mathematics education in schools aims not merely to enable students to perform calculations or memorize formulas, but to equip them with life skills through logical and critical reasoning. To navigate the increasingly complex challenges of the 21st century, every learner must possess six key skills and competencies: critical thinking, collaboration, communication, creativity, citizenship/culture, and character education/connectivity (Astuti, 2024). One of the cognitive abilities that serves as a primary focus in mathematics education is mathematical problem-solving.

According to Robert L. Solso (Hiskiawati et al., 2024), problem-solving is a form of thinking directly aimed at determining a solution or resolution for a specific problem. According to Gunantara (Lathifah & Yolanda, 2024), problem-solving ability refers to the skills or potential possessed by students to resolve problems and apply these solutions in their daily lives. According to (Anti & Kesumawati, 2019), mathematical problem-solving ability encompasses the capacity to identify known elements, the information sought, and the sufficiency of necessary components; to construct mathematical models; to select and develop problem-solving strategies; and to explain and verify the correctness of the obtained answers. Mathematical problem-solving ability is a primary focus of educational curricula; however, the reality in the field indicates that, in general, students' problem-solving abilities in Indonesia remain at a low level (Simamora & Saragih, 2019). This ability constitutes a crucial fundamental competency, as it trains students to understand problems, formulate mathematical models, implement problem-solving strategies, and review the results obtained based on problem-solving indicators (Khairani et al., 2021).

However, the reality on the ground indicates that students' mathematical problem-solving abilities generally remain low. Many students struggle when faced with non-routine problems that require in-depth analysis and high-level reasoning (Sukarso & Muslihatun, 2021). These difficulties often stem from classroom instruction that tends to remain conventional and teacher-centered. To support the effectiveness of student-centered learning, an innovative instructional model is needed one capable of creating a classroom environment that is interactive and supportive, while fostering students' freedom of thought without the fear of making mistakes.

One learning model considered highly effective for stimulating these cognitive aspects is the Osborn model integrated with the brainstorming technique. The Osborn model is an instructional approach centered on the process of generating new ideas or solving problems. It maximizes learners' ability to construct their own knowledge while addressing existing problems. When combined with brainstorming, the Osborn model serves as an active learning approach that focuses on fostering learners' creativity in generating ideas without the fear of criticism. The brainstorming technique was popularized by Alex F. Osborn in his book, *Applied Imagination*; the term refers to the process of generating new ideas or solving problems. Since the goal of any teaching strategy is to facilitate learning, the brainstorming strategy specifically seeks to engage all learners in generating their own ideas by accessing prior knowledge and information, while promoting active learning through mental engagement and spontaneous discussion to discover new opinions, ideas, and perspectives (Ghabanchi & Behrooznia, 2014).

According to (Novyanti & Alinurdin, 2019), brainstorming is a creative thinking technique that fosters creative thought. This activity encourages learners to generate a wide range of creative ideas. While brainstorming is frequently employed in group discussions to solve problems, it can also be conducted individually. Research by (Ayuningsih et al., 2025b) indicates that the Osborn model is effective in training learners to think creatively and solve problems, as it focuses on idea development through brainstorming techniques.

Literature reviews demonstrate that the Osborn learning model consistently prioritizes idea generation free from initial criticism that might undermine students' confidence making it a key solution for enhancing 21st-century problem-solving skills (Ayuningsih et al., 2025a). By employing the brainstorming technique within the Osborn framework, all student-generated ideas are freely accepted; this approach eliminates anxiety while simultaneously stimulating flexibility in

mathematical thinking (Tama et al., 2020). Scientifically, the implementation of this interactive brainstorming method has been shown to boost mathematical literacy by fostering a classroom atmosphere that is both enjoyable and meaningful (Komarudin & Suherman, 2024).

Beyond the choice of learning model, student success in mathematical problem-solving is inextricably linked to internal factors specifically, the students' own affective aspects. One of the most dominant psychological factors influencing this cognitive performance is self-efficacy. Student self-efficacy refers to an individual's belief in their own ability to successfully complete challenging mathematics tasks (Faozan, 2023). Observations confirm that students with high self-efficacy demonstrate persistence, strong motivation, and far more effective problem-solving strategies, whereas those with low self-efficacy tend to avoid complex tasks and doubt their personal competence (Saefuloh et al., 2026). Therefore, it is essential to conduct an in-depth examination of the problem-solving performance of eighth-grade students taught using the Osborn model with brainstorming techniques, specifically in relation to their levels of self-efficacy.

While extensive research has been conducted on the Osborn model, brainstorming techniques, and self-efficacy individually, studies specifically combining the Osborn model with brainstorming techniques to examine students' mathematical problem-solving abilities through the lens of self-efficacy remain very limited. Against this backdrop, this study aims to analyze and describe students' mathematical problem-solving abilities viewed from the perspective of self-efficacy through the implementation of the Osborn model combined with brainstorming techniques. The findings are expected to offer both theoretical and practical contributions to educators in designing mathematics instruction that not only hones cognitive skills but also strengthens students' psychological aspects.

METHOD

This study employs a mixed-methods approach using a sequential explanatory design that combines quantitative experimental and qualitative descriptive methods in a sequential manner. The quantitative phase utilizes a quasi-experimental Pretest-Posttest Control Group Design involving two classes an experimental group and a control group selected via cluster random sampling from the population of eighth-grade junior high school classes. The experimental class received instruction based on the Osborn model incorporating brainstorming techniques, while the control class underwent discovery learning. Quantitative data were gathered using pretest and posttest essay instruments designed to assess mathematical problem-solving skills based on specific problem-solving indicators, alongside a non-test instrument a Likert-scale questionnaire to measure students' self-efficacy levels.

Pada tahap kualitatif, dipilih 6 subjek dari kelas eksperimen menggunakan teknik *purposive sampling* yang mewakili masing-masing siswa dari kategori *self-efficacy* tinggi, sedang, dan rendah. Data kualitatif diperoleh melalui wawancara semi-terstruktur guna mengklarifikasi proses berpikir siswa dalam menyelesaikan soal tes pemecahan masalah. Teknik analisis data kuantitatif dilakukan melalui uji prasyarat normalitas-homogenitas yang dilanjutkan dengan uji-t independen pada nilai N-gain untuk melihat signifikansi peningkatan kemampuan pemecahan masalah antar-kelompok. Sementara itu, analisis data kualitatif menggunakan model Miles dan Huberman (pengumpulan data, reduksi, penyajian data, dan penarikan kesimpulan) untuk memperdalam, mengelaborasi, dan mengonfirmasi hasil temuan angka kuantitatif dari perspektif *self-efficacy* siswa.

RESULTS AND DISCUSSIONS

Results and Discussion of Quantitative Data

Quantitative data analysis was conducted to examine the effect of the Osborn learning model—incorporating the brainstorming technique—on the mathematical problem-solving abilities of eighth-grade students regarding measures of central tendency and data dispersion. Prior to hypothesis testing (t-test), normality testing using the Kolmogorov-Smirnov method and homogeneity testing using Levene's Test were performed on the N-gain scores of both groups to ensure that the assumptions for parametric statistics were met. A summary of the mathematical problem-solving ability scores and N-gain values is presented in Table 1.

Table 1. Summary of KPMM Scores and N-Gain Values

Group	Aspect	Pretest	Posttest	N-Gain
Experiment	Average	75,59	85,28	0,43
	Max Score	95	100	
	Min Score	60	70	
Control	Average	77,56	81,68	0,32
	Max Score	90	100	
	Min Score	65	70	

Based on the Kolmogorov-Smirnov calculation results, the significance (sig) values obtained were 0.200 for the control class and 0.106 for the experimental class. Data are considered to originate from a normally distributed population if the significance values for both classes exceed the significance level. Since the significance value for the control class $= 0{,}200 > 0{,}05$ and the significance value for the experimental class $= 0.106 > 0{,}05$, the data are derived from a normally distributed population. For the second prerequisite test the homogeneity test using Levene's Test a significance value $= 0.780 > 0{,}05$, it can be concluded that the experimental and control classes possess equal, or homogeneous variances.

Once the prerequisite tests were satisfied, hypothesis testing (t-tests) was conducted, comprising tests for mean mastery, proportion mastery, mean difference, proportion difference, linearity and regression, and finally, the N-Gain test. The first hypothesis test (t-test) yielded a calculated $t_{value} = 4{,}317 > t_{value} = 1{,}670$ thus, it can be concluded that the students' mean mathematical problem-solving score under the Osborn model with the brainstorming technique exceeded the mastery threshold (KKTP) of 80. For the second hypothesis test proportion mastery calculations were obtained for experimental clas $z_{values} = 2{,}881 > z_{table} = 1{,}645$ and control class $Z_{values} = 2.041 > z_{table} = 1{,}645$. Based on the calculation results, it can be seen that the calculated z_{value} for both classes exceeds the z_{table} value; therefore, it can be concluded that students receiving Osborn's instruction with the brainstorming technique achieved a mastery level exceeding 75%.

For the third hypothesis test a test of the difference between means calculations yielded a calculated $z_{value} = 2.676 > Z_{table} = 1.645$. Thus, it can be concluded that the mean score of the experimental class is higher than that of the control class. Next, the test for the difference in proportions yielded values of $\pi_1 = 32$, $\pi_2 = 32$, $\hat{p} = 0.765$, and $\hat{q} = 1.645$. Based on these values, the calculated $z_{value} = 2.676 > z_{table} = 1645$ therefore, it can be concluded that the proportion of students achieving mastery in the class taught using the Osborn model with brainstorming techniques is higher than in the class taught using the discovery learning model. The fifth hypothesis test involved linearity and regression analysis, used to determine whether a relationship exists between self-efficacy and students' problem-solving abilities. Calculations yielded an $F = 13.666$ with a significance value of 0.001. Since the significance value $0{,}001 < 0.05$, this indicates the presence of a relationship between self-efficacy and students' problem-solving abilities. The final hypothesis test was the N-Gain test, conducted to determine whether the average improvement in problem-solving in the experimental class exceeded that of the control class. Calculations yielded a calculated $t_{value} = 16.833 > t_{table} = 1{,}670$, with a significance level $= 0.05$; since $t_{value} > t_{table}$, it can be concluded that the average improvement in the experimental class is greater than the average improvement in the control class.

Results and Discussion of Qualitative Data

A total of 32 students from the experimental class (VIII-K) were classified based on their self-efficacy levels using a self-efficacy scale comprising 35 statements.

Table 2. Presentation of Students' Mathematical Problem-Solving Results Based on Self-Efficacy

Number of students	Self-Efficacy Scale	Category
7	$\geq 118{,}67$	High
18	$93{,}33 < x < 118{,}67$	Medium
7	$\leq 93{,}33$	Low

Table 2 shows that 7 students have high self-efficacy as well as moderate self-efficacy, and 18 students have low self-efficacy.

Problem-Solving Ability of Students with High Self-Efficacy

Student success in solving mathematics problems is clearly evident in their work. This serves as a strong indicator of an individual's cognitive ability to comprehend complex problems and efficiently formulate solutions. Furthermore, students with high levels of self-efficacy demonstrate the ability to correctly apply problem-solving steps. During the problem-comprehension stage, subject S-1 was able to fully document all raw data, frequencies, and the specific questions asked. In the planning and execution stages, S-1 appropriately selected the formulas for the combined mean and quartiles, and performed algebraic calculations systematically and confidently. Finally, S-1 independently verified the answer using the back-substitution method. Similarly, subject S-2 demonstrated the ability to successfully complete all stages of problem-solving. Despite minor inaccuracies in the calculation process, S-2 was generally able to correctly execute every phase of the mathematical problem-solving process—ranging from understanding the problem, formulating a mathematical model, and implementing a solution strategy, to verifying the accuracy of the answer. This aligns with Bandura's theory (Subaidi et al., 1993), which posits that high self-belief fosters persistence and optimal cognitive accuracy.

Problem-Solving Ability of Students with Moderate Self-Efficacy

Based on the test results and interviews with subjects S-3 and S-4, it is evident that Subject S-3 possesses adequate self-confidence but tends to hesitate when faced with non-routine problems. Furthermore, while students with moderate self-efficacy are capable of grasping the fundamentals of mathematics problems, S-3 and S-4 lacked precision in understanding the specific points of the questions, leading to erroneous conclusions. Additionally, S-3 and S-4 were inconsistent in identifying problems and tended to skip the re-evaluation stage.

Problem-Solving Ability of Students with Low Self-Efficacy

Based on test results and interviews, subjects S-5 and S-6 exhibited high levels of mathematics anxiety and a sense of resignation before even attempting the tasks. Analysis of the test results, interviews, and observations revealed that subject S-5 lacked competence, consistently making errors starting from the initial stage of problem comprehension. S-5 also demonstrated inaccuracies when executing solution plans for the majority of the problems and neglected to review the work. Consistent with these findings, subject S-6 displayed identical competency deficits. S-6's difficulties ranged from shortcomings in identifying the problem, formulating and implementing a mathematical model, to accurately conducting a final review of the work.

CONCLUSION

Based on the quantitative and qualitative data analysis presented, the study concludes that: (1) The implementation of the Osborn learning model using the brainstorming technique was of high quality and effective, evidenced by the achievement of class-wide mastery and an improvement in students' mathematical problem-solving abilities to the moderate category; (2) Self-efficacy positively influenced students' mathematical problem-solving abilities within the Osborn learning model using the brainstorming technique; (3) Students with high self-efficacy (S-1 and S-2) demonstrated comprehensive mastery across all problem-solving indicators. Generally, these two students exhibited a deep understanding of problem structures, constructed mathematical models accurately, and implemented solution strategies systematically according to their plans. Furthermore, S-1 and S-2 demonstrated high-level metacognitive skills, evidenced by their ability to validate, re-explain, and verify the accuracy of the solutions obtained; (4) Students with moderate self-efficacy (represented by subjects S-3 and S-4) showed partial problem-solving performance. Analysis revealed that both subjects faced challenges during the initial stage, specifically regarding the suboptimal documentation of their understanding of the problem. Nevertheless, S-3 and S-4 proved capable of constructing mathematical models and executing previously planned solution strategies. The most critical obstacle arose during the final phase; neither subject was able to substantially confirm or evaluate the validity of their solutions, despite the presence of formal indicators—such as the written claim "I have checked this answer"—on their worksheets; (5) An in-depth analysis of the low self-efficacy group (S-5 and S-6) confirmed the presence of systematic obstacles across nearly all stages of the problem-solving process. In the initial phase, both subjects struggled to explicitly articulate their understanding of the problem, as evidenced by their inability to list the given information and the quantities to be determined.

This obstacle led to a failure to complete the mathematization stage or to formulate a relevant mathematical model. Furthermore, S-5 and S-6 consistently made errors when implementing solution strategies and showed a tendency to take shortcuts by simply stating the final result without showing a logical calculation process. Finally, during the evaluation phase, neither subject was able to verify or explain the accuracy of their answers. Their review activity was superficial, consisting merely of the perfunctory statement "I have checked this answer," with no indication of actual correction.

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