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# Implementation of Open-Ended Approach in Mathematics Learning to Improving Self-Regulated Learning of Vocational High School Students

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**Abstract**

This study seeks to evaluate the efficacy of an open-ended approach to mathematics instruction in enhancing the learning autonomy of Vocational High School (SMK) students. This research employs a quasi-experimental methodology with a pretest-posttest control group framework, encompassing two cohorts of class XI Computer Network Engineering students (TKJ 1 and TKJ 2). The sample comprised 72 students, who were allocated into an experimental group and a control group. Data about student self-regulated learning were gathered using a questionnaire comprising 36 items, which were subsequently evaluated using statistical tests facilitated by SPSS version 30. The findings indicated that the experimental group employing an open-ended methodology had a more pronounced enhancement in learning autonomy relative to the control group. This discovery demonstrates that the open-ended method effectively enhances student learning autonomy, which is crucial for equipping them to navigate the evolving workforce. The current degree of student self-regulated learning remains low, indicating a necessity for the introduction of advanced ways to enhance the capacity for long-term autonomous learning among students.

**Keywords:** mathematics learning, open-ended approach, self-regulated learning, vocational high school, quasi-experiment

## 1. Introduction

Vocational High Schools (SMK) play a crucial role in human resource development, particularly in equipping trained workers for the increasingly dynamic industrial and economic sectors. SMK aims to significantly contribute to economic development by creating graduates equipped with practical skills that align with labor market demands through vocational education. This education

aims not only to decrease youth unemployment but also to provide SMK graduates with skills pertinent to the evolving industry demands (Depdiknas, 2009).

In conjunction with the government's initiatives to enhance educational quality, vocational schools have experienced several modifications in curriculum, infrastructure, and pedagogical approaches. Vocational school education prioritizes the acquisition of specialized skills in fields such as engineering and business, as opposed to the theoretical concentration of Senior High Schools (SMA). Enhancing the quality of vocational education in vocational schools is crucial for enabling graduates to promptly participate to the workforce without necessitating additional time to acquire essential skills (Suyanto, 2016).

The importance of evaluating the relevance of vocational school curriculum to the needs of the workforce is increasingly felt. The Indonesian government has launched various programs to strengthen the quality of vocational school education, such as developing competency-based curriculum and increasing partnerships between vocational schools and industry (Rizal & Indrawati, 2015). However, despite efforts to improve, challenges related to implementing a curriculum that is in line with industrial developments remain. The need to evaluate and develop this education policy is very urgent so that vocational schools can produce graduates who are in line with rapidly changing market demands.

Nonetheless, a substantial disparity persists between the curriculum employed in vocational schools and the evolving demands of the business. Numerous vocational school programs have not adequately synchronized education with industry changes, resulting in graduates frequently encountering challenges in securing employment that corresponds with their skill set. The Ministry of Education and Culture (Kemdikbud) has implemented the 2013 Curriculum to address this need; however, its execution encounters numerous challenges, including a disparity between the curriculum content and the technological skills and competencies required in the industrial sector (Kemdikbud, 2020).

In addition, limited infrastructure and practical facilities in vocational schools are also a serious problem. Many schools, especially in remote areas, lack the equipment and technology needed to support practical activities that are in line with industrial developments. This results in students, even though they have mastered the theory, not getting enough practical experience to prepare them for the world of work. Based on a report from BPS (2021), more than 60% of vocational schools in less developed areas still lack adequate practical facilities.

The caliber of instruction in vocational schools is a crucial element in producing proficient graduates. Nevertheless, the majority of vocational school instructors lack qualifications aligned with contemporary technological and industrial advancements. A significant number do not participate in regular professional training, resulting in potentially outdated material being taught. According to data from the Association of Vocational Education Teachers (2022), around 40% of vocational school instructors in Indonesia have not participated in professional development training in the past five years, adversely affecting classroom teaching quality.

In addition to the quality of teaching, the unemployment rate among vocational school graduates is still quite high, also reflecting the gap between the education provided and the needs of the labor market. Vocational school graduates often do not have the relevant skills or sufficient work experience to enter the workforce smoothly. The Central Statistics Agency (BPS, 2023) reported that around 12% of the total unemployed in Indonesia come from vocational school graduates, indicating the need to adjust the curriculum to be more in line with industry demands.

The absence of robust collaborations between vocational institutions and the industry sector hinders the enhancement of vocational education's usefulness. Numerous vocational schools lack robust connections with industry, resulting in insufficient internship chances for students to enhance their practical abilities. The Ministry of industrial (2021) disclosed that approximately 30% of vocational schools in Indonesia lack industrial ties, hence impeding the enhancement of student competences in the sector.

Alongside external variables, the restricted motivation and capacity of students to engage in independent learning are significant challenges in enhancing their competencies. A significant number of vocational high school students lack the practice of independent study beyond school hours and are frequently ensnared in routines that impede their self-development. A diminished willingness to pursue learning beyond the classroom is associated with an inadequate comprehension of the significance of autonomous skills for career success (Sutrisno, 2020).

Another factor that influences the development of self-regulated learning is the limitation in managing time, especially for students who are involved in part-time jobs or extracurricular activities. This makes it difficult for them to allocate time for self-regulated learning. Aulia (2021) stated that many vocational high school students do not yet have effective time management skills, which in turn has an impact on their low level of independence in learning.

Access to resources and facilities that support independent learning is also a major obstacle. Many vocational high school students do not have stable internet access or interactive learning materials outside the classroom, which limits their opportunities to explore and deepen their knowledge (Budiarto, 2022). This hinders them from developing optimal self-regulated learning, even though they have great potential to improve their skills outside of school hours.

Limited guidance and mentoring outside of class hours is also a factor that hinders the development of student self-regulated learning. In many vocational schools, especially in less developed areas, the role of mentors is often limited. Without sufficient guidance, students will have difficulty overcoming problems that arise in the independent learning process. Lestari (2023) stated that the limited number of mentors or tutors outside of class hours affects the low level of student independence.

A structured teaching methodology that depends on direct instruction from educators hinders the cultivation of students' learning autonomy. Educational approaches that restrict students' opportunities for creative thinking and independent problem-solving adversely affect their motivation for autonomous learning (Wahyuni, 2020). Consequently, it is imperative to implement

a more adaptable method that enables students to engage actively in the learning process, so enhancing their autonomy.

To overcome this challenge, an open-ended approach to mathematics learning can be an effective solution. This approach provides opportunities for students to develop learning independence, by giving them the freedom to solve problems in various ways (Schoenfeld, 2016). Research shows that this method can increase students' motivation and encourage them to self-regulated learning, which in turn can improve their learning outcomes (Boruchovitch, 2014; Leung, 2013). The implementation of this approach is expected to improve the quality of education in SMK and prepare students to face the challenges of an increasingly complex world of work.

## 2. Methods

This study seeks to evaluate the efficacy of an open-ended strategy in enhancing students' learning autonomy, particularly in mathematics education. This study used a quasi-experimental design using a pretest-posttest control group, consisting of two groups. The experimental group received a learning intervention characterized by an open-ended methodology that prioritized the investigation of open problems, whereas the control group engaged in a direct instructional approach that concentrated on the systematic presentation of material by the instructor. This research methodology is quasi-experimental, as the selection of subjects for each group was not random but based on pre-existing classes, specifically class XI Computer and Network Engineering (TKJ) at the examined vocational school (Ary, Jacobs, & Sorensen, 2010; Creswell, 2012).

The selection of research participants considered actual field settings, namely without altering the existing class organization, to accurately represent the situation in the school. The experimental group engaged in an open-ended learning strategy, enabling students to explore answers to challenges presented freely, whereas the control group experienced a direct learning approach, with the teacher delivering content in a more planned and organized manner. Questionnaires were administered to both groups to assess students' self-regulated learning prior to the commencement of instruction. The questionnaire was administered again post-intervention to assess the degree of development in their learning independence following the treatment.

The research sample comprised 72 grade XI students from a vocational high school in Pandeglang Regency, recruited by purposive sampling technique. The experimental group comprised of students of grade XI Computer Network Engineering 1 (TKJ 1) totaling 36 students, while the control group consisted of students of grade XI Computer Network Engineering 2 (TKJ 2) likewise totaling 36 students. The instrument employed in this study was a self-regulated learning questionnaire using a Likert scale comprising 36 statements. Out of the 36 statements, 18 have been validated as positive and 18 as negative.

The collected data were further examined employing statistical tests, such as normality tests, homogeneity of variance tests, and comparisons between experimental and control groups, utilizing SPSS software version 30 at a significance level of 5% ($\alpha = 0.05$). This study used N-gain data to

assess the enhancement of students' self-regulated learning. This investigation aimed to ascertain if a significant difference existed in the enhancement of self-regulated learning before and after the treatment was administered.

## 3. Result and Discussion

The data description about the enhancement of students' self-regulated learning encompasses comprehensive details on the sample size, mean pretest score, mean posttest score, mean N-Gain score, and standard deviation. This data is offered to offer a more precise depiction of the diversity in the enhancement of self-regulated learning within each group. Table 1 summarizes the descriptive data, offering significant insights into the variations in students' learning independence prior to and during the implementation of the employed approach. This investigation assesses the efficacy of the learning technique in fostering students' learning autonomy.

**Table 1.**
*N-Gain Description of Self-Regulated Learning*

| Statistics | Open-Ended Approach | | | Direct Learning | | |
|---|---|---|---|---|---|---|
| | Pretest | Posttest | N-Gain | Pretest | Posttest | N-Gain |
| $N$ | 36 | | | | 36 | |
| $\bar{x}$ | 100,4881 | 101,6086 | ,0181 | 102,7936 | 100,9589 | -,0156 |
| $sd$ | 8,91709 | 12,04947 | ,06075 | 7,56848 | 13,96404 | ,08736 |

Table 1 delineates the average enhancement in students' learning autonomy within the open-ended method group, indicating an N-Gain value of 0.0181. In the learning group utilizing a direct strategy, the N-Gain value was -0.0156. Comparing the N-Gain values of the two groups reveals that the enhancement in students' self-regulated learning was superior in the group employing the open-ended strategy relative to the group utilizing the direct technique.

Prior to evaluating the disparities in the enhancement of self-regulated learning between the two groups, a preparatory assessment must be performed to ascertain the authenticity of the data. The initial stage is the normality test, which seeks to determine if the distribution of N-Gain data adheres to a normal distribution pattern. Upon confirming normal distribution of the data, the subsequent step involves conducting a homogeneity test to assess the equality of variance among groups. The homogeneity test is performed via the Levene test at a significance threshold of $\alpha = 0.05$ to ascertain the uniformity of variance among groups. Should the test findings indicate homogeneous variance, the examination of disparities in the enhancement of student learning independence may be performed utilizing parametric tests, such as the t-test. If the data is heterogeneous or not regularly distributed, the analysis proceeds with non-parametric tests, such as the Mann-Whitney U test. The normality of the data was assessed using the One-Sample Shapiro-Wilk (S-W) test, which is suitable for small to medium-sized samples. The outcomes of the normality test, displayed in Table 2, provide the statistical test values, significance, and interpretation of the N-Gain data distribution, which are crucial for identifying the suitable further statistical analysis.

**Table 2.**
*N-Gain Normality Data Self-Regulated Learning*

| Group | Shapiro-Wilk | | |
|---|---|---|---|
| | Statistic | df | Sig. |
| Open-Ended Approach | ,896 | 36 | ,003 |
| Direct Learning | ,942 | 36 | ,060 |

Table 2 presents the outcomes of the normality test for the N-Gain data regarding the self-regulated learning of the cohort of students who were subjected to the open-ended approach, with a significance value of 0.003 ($\alpha = 0.05$), indicating the rejection of H0. The N-Gain data for the cohort of students utilizing the open-ended technique is less than 0.05, indicating a non-normal distribution. The N-Gain data for the self-regulated learning of students who got the direct method indicates a significance level of Sig. = 0.060, which is greater than $\alpha = 0.05$, therefore leading to the acceptance of H0. Since the significance value exceeds 0.05, the N-Gain data for the cohort of students who underwent the direct technique is normally distributed.

Due to the normality test results indicating that the group of students employing the open-ended strategy was not normally distributed, a difference analysis was conducted utilizing a non- parametric test, namely the Mann-Whitney U test. This test was selected as it may compare two independent groups without necessitating the assumption of normal distribution in the data. Table 3 provides a comprehensive presentation of the Mann-Whitney U test results, encompassing the statistical test values, significant levels, and interpretations of the differences between the two groups on the enhancement of student self-regulated learning. This analysis offers a comprehensive evaluation of the efficacy of each learning method.

**Table 3.**
*N-Gain Mean Difference of Self-Regulated Learning*

| | Value |
|---|---|
| Mann-Whitney U | 406,000 |
| Wilcoxon W | 1072,000 |
| Z | -2,730 |
| Asymp. Sig. (2-tailed) | ,006 |

Table 3 displays the outcomes of the Mann-Whitney U statistical test, with an Asymp. Sig. (2- tailed) value of 0.006. Since the hypothesis under examination is one-tailed, specifically $H_0: \mu_1 \leq \mu_2$, the Asymp. Sig. (2-tailed) value must be halved, yielding a value of 0.006/2=0.003. This value is subsequently compared to the significance level ($\alpha = 0.05$), and thus $0.003 < 0.05$. Consequently, students engaged in an open-ended learning strategy exhibit superior self-regulated learning compared to those subjected to a direct learning approach across all student demographics. This verifies that the open-ended method is considerably more effective in enhancing student learning

autonomy than the direct method.
The specifics of the enhancement in learning autonomy, categorized according to Meltzer (2002), are comprehensively outlined in Table 4.

**Table 4.**
*Average Improvement in Self-Regulated Learning*

| Group | (N-Gain) | Category |
|---|---|---|
| Open-Ended Approach | ,0181 | Low |
| Direct Learning | -,0156 | - |

Table 4 indicates that, overall, the degree of student self-regulated learning remains in the low category. This suggests that pupils often depend on the assistance of teachers or others during the learning process, indicating that self-regulated learning remains a considerable issue. This circumstance necessitates a more rigorous and systematic approach to enhance student learning autonomy. The analysis results indicate that pupils exposed to an open-ended learning technique exhibited a greater enhancement in self-regulated learning than those utilizing a direct approach. The rise was found to be statistically significant according to the Mann-Whitney U test, with a significance value (Sig. = 0.003) that is less than the significance level ($\alpha = 0.05$). The pre-treatment questionnaire data corroborates the findings, indicating no significant difference in learning independence levels between the group utilizing the open-ended strategy and the group employing the direct technique. Following the implementation of the treatment, there was a marked enhancement in student learning autonomy. Nonetheless, the overall rise remained rather modest as assessed using the N-Gain value. This finding indicates that while the open-ended method positively influences self-regulated learning, additional efforts are required to attain a more significant enhancement.

An open-ended learning strategy significantly enhances students' self-regulated learning. This method is more effective than the direct approach in enhancing overall learning autonomy, according to the study's findings. This method enables students to actively investigate multiple potential solutions, thereby enhancing their comprehension of the issue. This strategy enhances students' critical thinking and autonomous problem-solving skills, hence fostering their autonomy in learning. This study's findings emphasize the necessity of tailoring the open-ended approach to the specific features of students and the conditions of their learning environment. This approach can effectively enhance self-regulated learning among vocational high school pupils. To attain optimal outcomes, this strategy may be integrated with additional learning approaches, facilitating the adjustment of material complexity to align with students' capabilities. Consequently, despite the numerous advantages of the open-ended approach, its efficacy remains contingent upon the characteristics of the learning environment. Educators must create flexible and adaptive ways to ensure that each student derives optimal benefits from this methodology.

## 4. Conclusion

This study demonstrates that pupils employing the open-ended strategy exhibit a greater enhancement in learning autonomy than those utilizing the direct technique. The open-ended method substantially enhances the learning autonomy of vocational high school students. This is seen in students' enhanced capacity to actively seek answers to assigned difficulties, take initiative in their learning process, and exhibit greater independence in addressing academic tasks. The open- ended approach, emphasizing the investigation of unresolved issues and fostering critical thinking among students, has demonstrated greater efficacy in enhancing learning autonomy than the more structured direct approach, which centers on the passive transmission of information by educators. This study demonstrates that the open-ended approach can foster greater student accountability for their own learning, encourage decision-making, and enhance confidence in articulating viewpoints or solutions to encountered challenges. This suggests that the open-ended approach enhances knowledge acquisition and fosters the development of students' cognitive and metacognitive skills, which are crucial for their future success in both higher education and the workforce.

This study's findings suggest that the open-ended approach should be more extensively implemented in vocational institutions, particularly in disciplines necessitating problem-solving and critical thinking skills development. To achieve effective implementation, educators must receive training in this technique to enable students to become more active, creative, and independent. Furthermore, the curriculum requires assessment and modification to facilitate open and authentic problem-based exploration of subjects. The utilization of varied educational tools, including technology and interactive media, is crucial for enhancing student motivation. Consistent evaluation of the progression of student learning autonomy must be conducted to determine the enduring effects of this methodology. These phases aim to maximally cultivate student self- regulated learning, equipping them to confront the difficulties of the workforce and advanced education.

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