Abdimas Umtas: Jurnal Pengabdian Kepada Masyarakat
LPPM-Universitas Muhammadiyah Tasikmalaya
Volume: 9, Issue: 1, January, 2026; pp: 39-50
E-ISSN: 2614 - 8544

Enhancing Mathematical Competence and HOTS Skills in Vocational Students Through Interactive Training: A Community Service Initiative

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ABSTRACT

This community service program focuses on enhancing the readiness of vocational high school students in facing the Academic Ability Test through strengthening mathematical competencies and higher-order thinking skills (HOTS). The background of this program lies in the gap between practical vocational learning and the conceptual–analytical nature of the Academic Ability Test. The program was designed to address issues related to students' low conceptual understanding and limited HOTS abilities. The methods employed include interactive training, intensive mentoring, and problem-based Academic Ability Test simulation activities, implemented at SMK Pratama Mulya Karawang. Evaluation results indicate that the program successfully improved students' mathematical competence, demonstrating a 29% increase, as reflected in the rise of the average score from 57.8 (pre-test) to 74.6 (post-test). A paired sample t-test confirmed that this improvement was statistically significant. This program not only enhanced students' cognitive abilities but also fostered their confidence. it is concluded that the hots-based interactive training model is effective in preparing vocational high schools students for the Academic Ability Test. Therefore, similar programs are recommended for wider implementation with contextual adjustments, and continuous development is needed to ensure long-term impact.

ARTICLE INFO

Article History:
Submitted/Received: 11-11-2025
First Revised: 28 November 2025
Accepted: 10 December 2025
First Available online: 31 January 2026
Publication Date: 31 January 2026

Keyword :
Academic Ability Test
Higher Order Thinking Skills (HOTS)
Interactive Training
Academic Readiness
Vocational High School Students
Community Service Program

https://doi.org/10.35568/abdimas.v9i1.7356

INTRODUCTION

Improving the quality of national education has become one of the main priorities of the Ministry of Education, Culture, Research, and Technology, as reflected in the implementation of the Academic Ability Test. Since the enactment of the Ministry of Primary and Secondary Education Regulation No. 9 of 2025, the Academic Ability Test has been developed as a standardized national assessment aimed at measuring students' academic achievement across various educational levels, including vocational high schools (Kemendikdasmen, 2025). Unlike previous national examinations that emphasized memorization, the TKA requires Higher-Order Thinking Skills (HOTS), including logical reasoning, problem-solving, and contextual mathematical representation.

However, the implementation of the Academic Ability Test at the vocational level presents several challenges. Vocational high school students are typically more accustomed to vocational learning that emphasizes practical and technical applications, whereas the Academic Ability Test focuses more on conceptual and analytical abilities. This mismatch creates an academic gap that affects students' readiness to face the assessment. Disparities in school quality, psychological pressures related to competition, and the misalignment between the vocational high schools' curriculum and the Academic Ability Test question formats further exacerbate this issue. Many students with strong academic potential are not yet familiar with the abstract reasoning required to solve analytical problems.

Strengthening mathematical competence among vocational high school students has therefore become increasingly urgent in line with evolving demands in vocational education. To address this, various interactive learning approaches have been introduced to replace traditional mathematics instruction, which tends to rely heavily on rote learning. Interactive approaches such as collaborative learning and blended problem-based learning have been shown to effectively improve vocational high school students' critical thinking and problem-solving abilities. These findings highlight that learning methods emphasizing interaction and problem-solving can overcome the limitations of conventional approaches.

Cooperative learning models implemented in vocational high schools, as described by Lu (2023), enable students to work collaboratively in solving mathematical problems, creating an inclusive learning environment that supports critical thinking development. Moreover, Matondang et al. (2024) report that training in rapid-calculation strategies not only improves speed and accuracy in problem-solving but also builds students' confidence in applying mathematics in their future professions.

Thus, interactive learning benefits both academic achievement and professional readiness.

In addition, Muhrman (2022) emphasizes the importance of mathematics education as a foundation for applicable knowledge that is useful not only in school but also in everyday life. The use of educational technologies such as Computer-Based Virtual Learning Environments (CBVLE) has been shown to enhance mathematics learning, particularly for students who require mathematical competencies in professional fields such as healthcare (Zwart, 2021). These developments reflect a shift toward more digital and technology-based education. In the context of vocational education, competency-based approaches that emphasize mathematical problem-solving are also important. Shen (2023) highlights that mathematics instruction rooted in critical thinking and problem-solving can enhance students' ability to confront professional challenges. Such approaches accelerate the acquisition of relevant skills and encourage active student engagement.

Overall, interactive learning approaches have been proven effective in strengthening mathematical

https://doi.org/10.35568/abdimas.v9i1.7356

competence among vocational high school students and preparing them for the workforce. Therefore, integrating these approaches into vocational education curricula should be a priority to enhance students' critical thinking and problem-solving skills.

Recent studies underscore the urgency of strengthening mathematical competence in the context of national assessments. Prior research has demonstrated that contextual and problem-based learning approaches can improve students' mathematical literacy (Dhiyazzahra et al., 2023; Setyowati & Nurcahyo, 2023; Turidho et al., 2021). The Missouri Mathematics Project (MMP) model has been effective in building students' confidence and active participation in mathematics learning, while problem-based learning and mind-mapping approaches have improved conceptual understanding and retention (Abubakar et al., 2021). Julie et al. (2022) and Mailizar & Fan (2019) highlight the importance of teacher competency in integrating technology into mathematics instruction, especially as most academic ability test questions are now administered digitally.

Higher-Order Thinking Skills (HOTS) in Mathematics Education

The development of Higher-Order Thinking Skills (HOTS) has been widely recognized as a critical factor in improving student performance, particularly in mathematics learning. HOTS involve the ability to analyze, evaluate, and solve problems critically and creatively, skills that are essential for both academic achievement and professional competence. Numerous studies show that enhancing HOTS can significantly improve students' performance in mathematics, especially in vocational education settings. Purnama & Nurdianingsih (2019) highlight that explicit instruction in HOTS can enhance students' critical thinking, which in turn improves learning outcomes in mathematics. Similarly, a meta-analysis by Utami et al. (2022) shows that problem-based learning (PBL) effectively develops HOTS by encouraging deep critical reasoning and the application of knowledge in meaningful contexts.

Furthermore, the Realistic Mathematics Education (RME) approach, which emphasizes context-based problem-solving, has also proven effective in improving students' HOTS. RME helps students relate mathematical concepts to real-world situations, which is particularly relevant in vocational education. Suryono et al. (2023) found that this approach enhances essential higher-order thinking skills needed for solving applied mathematical problems. Additional evidence from Alhakiki & Miaz (2023) shows that HOTS development not only strengthens students' numerical abilities but also enables them to analyze, synthesize, and evaluate complex mathematical problems. These skills are highly relevant for vocational high school students who must apply mathematics in professional contexts.

Overall, the development of HOTS through innovative approaches such as PBL and RME is effective in improving higher-order thinking and mathematics learning outcomes among vocational high school students. Thus, it is important to explore how training based on these methods can further develop vocational high school students' mathematical competence and HOTS, and prepare them to tackle professional challenges.

Beyond pedagogical approaches, the characteristics of vocational students must also be considered. Vocational high school students tend to respond better to practical, visual, and interactive learning rather than abstract mathematics instruction. Learning environments that support Social and Emotional Learning (SEL) have been shown to increase students' motivation and confidence in tackling challenging problems. Therefore, interventions aimed at strengthening mathematical abilities among vocational high school students should be multidimensional, involving cognitive, affective, and contextual aspects.

In preparation for the Academic Ability Test, innovative learning models such as Somatic, Auditory,

https://doi.org/10.35568/abdimas.v9i1.7356

Visual, and Intellectual (SAVI) have been shown to improve student engagement and conceptual understanding (Afnida & Utami, 2024). Such approaches allow students to process information through multiple sensory and intellectual pathways, aligning with TKA demands that combine reasoning speed, reading comprehension, and numerical analysis. However, few community service programs directly implement HOTS-based mathematics strengthening for vocational high school students in the context of the TKA, revealing a gap between research and practice.

Problem Statement

Despite extensive research highlighting the effectiveness of interactive learning in improving HOTS and mathematical competence, the implementation of structured interactive training in vocational education remains limited, particularly in community-based learning contexts. For example, Zwart (2021) emphasizes the importance of collaborative learning environments in vocational education, yet the study does not examine the sustainability of HOTS improvements after intervention. Similarly, Sembiring & Napitupulu (2022) note that while interactive worksheets effectively enhance HOTS, their application in more diverse community learning environments is still limited.

Moyo et al. (2022) demonstrate the potential of formative assessment in strengthening HOTS, but no studies have systematically integrated such assessments into vocational programs or community service initiatives. Likewise, Rahmadhani & Wirayuda (2023) report that although HOTS development is understood conceptually, appropriate training methodologies for non-traditional learning environments remain underexplored.

The main issue addressed in this community service program is the low readiness of vocational high school students in facing the Academic Ability Test, particularly in higher-order thinking skills and conceptual mathematical competence. Additionally, vocational high school teachers require support in the form of effective learning models and practice materials aligned with the Academic Ability Test format to ensure more efficient and relevant classroom instruction that meets national assessment demands.

Research Questions

Based on the identified gap, this community service initiative seeks to answer the following questions:

- How can HOTS-based interactive training improve vocational high school students' mathematical competence?
- What is the impact of HOTS-based training on vocational high school students' academic readiness for the Academic Ability Test (TKA)?

Based on these considerations, this article proposes and reports the implementation of the program "Enhancing Mathematical Competence and HOTS Skills in Vocational Students Through Interactive Training: A Community Service Initiative" as a tangible contribution from higher education institutions to improving the quality of vocational education. The program focuses on training, mentoring, and problem-based TKA simulations using HOTS approaches, supported by interactive media and reflective strategies tailored to the characteristics of vocational high school students.

This community service initiative aims to evaluate the effectiveness of interactive training in improving mathematical competence and HOTS among vocational high school students. The program is

https://doi.org/10.35568/abdimas.v9i1.7356

designed to enhance students' academic readiness and strengthen their ability to solve mathematical problems aligned with the Academic Ability Test format. The primary contribution of this initiative is the development of a replicable interactive training model to improve vocational high school students' mathematics competence and HOTS, offering a community-based approach relevant to vocational education needs. Its novelty lies in the integration of community-based interactive training that simultaneously develops mathematical competence and HOTS, a comprehensive approach that remains underexplored in previous community engagement programs.

The objective of this community service program is to enhance vocational high school students' conceptual understanding and higher-order thinking skills in mathematics to better prepare them for the Academic Ability Test. Through this initiative, students not only receive conceptual reinforcement but also experience interactive learning and direct Academic Ability Test simulations. This approach is expected to strengthen their critical and analytical thinking, build their confidence in solving reasoning-based problems, and prepare them psychologically to remain calm, focused, and adaptive during the exam. Thus, this program serves as a strategic effort to build comprehensive academic and mental readiness among vocational high school students. It is anticipated that this initiative will enhance students' academic preparedness, reduce disparities in educational quality across regions, and reinforce the implementation of the Academic Ability Test as an inclusive and equitable national education quality assurance instrument.

RESEARCH METHODS

The methods employed in this community service program were designed to address the low academic readiness of vocational high school students in facing the Academic Ability Examination (UKA), particularly in the areas of higher-order thinking skills (HOTS) and conceptual mastery of mathematics. The approach used was analytical, participatory, and experimental in nature, emphasizing active student engagement through interactive learning and problem-based simulations.

This activity was carried out in collaboration with SMK Pratama Mulya Karawang, located in Kutapohaci Village, Ciampel Subdistrict, Karawang Regency, West Java. This partner institution was selected because its students come from diverse academic and vocational backgrounds, making it an appropriate setting for implementing a HOTS-based mathematics reinforcement model for UKA preparation.

Participants

The participants of this program were 55 twelfth-grade students from SMK Pratama Mulya Karawang, representing various vocational expertise programs. Their fields ranged from engineering to office administration. The selection of participants was based on their needs in preparing for the Academic Ability Examination, as well as the importance of strengthening higher-order thinking skills in solving complex mathematical problems.

Instruments

The instruments used in this program consisted of practice questions designed to develop students' HOTS and conceptual understanding of mathematics. The items were constructed to assess analytical,

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evaluative, and problem-solving abilities within mathematical contexts. Examples of the practice questions include:

Sample Items:

- Determine the value of $\frac{1}{4}+\frac{7}{4}\times\frac{8}{21}$.
- The sum of two positive odd integers is 40 and their difference is 6. Determine which of the following statements are correct by marking (✓) the appropriate boxes. More than one answer may be correct:
  - ✓ The larger integer is greater than 20
  - ✓ The smaller integer is less than 20
  - ✓ The larger integer is composite
  - ✓ The smaller integer is prime
- In celebration of Teacher's Day, a school will hold a drama performance in a hall. The seating consists of several rows with different numbers of seats. The second row contains 32 seats, while the tenth row has 48 seats. If the number of seats forms an arithmetic sequence, in which row are there 68 seats?
- Given cube PQRS.TUVW with edge length 8, determine the tangent of the angle between lines TR and PS.
- The average score of 17 students is 83. Three additional students take a make-up exam, resulting in a new average of 82 for all 20 students. Determine which of the following statements are correct by marking (✓) the boxes. More than one answer may be correct:
  - ✓ The total score of the three additional students is 229
  - ✓ Their average score is greater than 70
  - ✓ The lowest score among the three is not less than 29
  - ✓ The highest score among the three is more than 76
  - ✓ The score range of the three students is greater than 71

In addition to the test items, other instruments included short quizzes, self-reflection prompts, and direct feedback from the teaching team to reinforce students' understanding.

Procedure

The program was implemented using a structured and systematic instructional strategy consisting of the following stages:

- Interactive Learning

  Students actively engaged in discussions, question-and-answer sessions, and short quizzes to encourage participation and build confidence in mathematical reasoning.

- Focus on HOTS Development

  Students were provided with exercises targeting higher-order thinking skills—such as analytical and evaluative problem-solving—that required advanced reasoning.

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- Mini UKA Simulation

  Students participated in timed exercises that resembled the format of the Academic Ability Examination, helping them practice problem-solving strategies and time management.

- Guided Instruction and Immediate Feedback

  The teaching team provided step-by-step guidance and real-time feedback on students' work to strengthen their conceptual mathematics understanding.

- Reflection and Independent Learning Strategies

  Students were encouraged to reflect on their learning experiences and identify effective study strategies. Additional study guides were provided to support continued independent learning after the program.

Data Analysis

The data analysis method used in this program was comparative descriptive analysis, comparing pre-test and post-test results to evaluate improvements in mathematics performance and higher-order thinking skills after the intervention. The analysis involved calculating differences in average pre-test and post-test scores to identify significant changes.

The statistical technique employed was the paired sample t-test, used to determine whether there was a significant difference between students' pre-test and post-test scores. This test was appropriate because the data consisted of paired observations (pre-test and post-test scores from the same participants), making it suitable for measuring changes in mathematical ability and HOTS.

$$t = \frac{\bar{d}}{s_d/\sqrt{n}} \quad (1)$$

In addition, a qualitative analysis was also conducted by examining participants' reflections and feedback to evaluate the effectiveness of the learning approach implemented.

Ethical Considerations

Throughout the implementation of this program, ethical standards were strictly maintained. All participants were clearly informed about the purpose of the activity, as well as their rights and responsibilities as participants. Information obtained during the activity was used solely for this community service program and for the improvement of similar programs in the future. All collected data, both quantitative and qualitative, were kept confidential and accessible only to the instructional team involved in the program. Participants were also allowed to provide voluntary informed consent before joining the activity and were assured that they could withdraw at any time without any consequences.

RESULT AND DISCUSSION

Results of Activity Implementation

This community service activity was carried out on August 25, 2025, at SMK Pratama Mulya Karawang, involving a total of 32 participants from grades XI and XII representing various vocational

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study programs. The main goal of the program was to enhance students' academic readiness for the academic ability test, particularly in numerical skills, logical reasoning, and Higher-Order Thinking Skills (HOTS).

The implementation of the activity was divided into several stages. The first session began with an opening and an introduction to the concept of the academic ability test, including an explanation of its purpose, question format, time allocation, and the relevance of the assessed competencies to academic demands and the workplace. This session concluded with an ice-breaking activity and a pre-assessment in the form of a short mathematics quiz to map students' initial abilities. Initial results indicated that most students struggled with questions requiring logical patterns and complex numerical reasoning.

The core stage of the program focused on strengthening mathematical concepts, emphasizing four main topics commonly found in academic ability tests: algebra, geometry, logic, and statistics. The explanations highlighted key concepts, efficient problem-solving techniques, and HOTS-based examples. Each topic presentation was followed by individual and group exercises, as well as guided discussions. Students demonstrated active participation, particularly in developing problem-solving strategies, while lecturers and teachers provided direct feedback to correct conceptual misunderstandings.

Academic Ability Test Simulation

After the material sessions, a mini simulation of the academic ability test was conducted, consisting of 10 questions to be completed within 15–20 minutes, mirroring actual test conditions. The simulation results indicated improvements in students' speed and accuracy in understanding and answering questions, although some students still faced challenges related to time management and question interpretation. Table 1 below presents descriptive data on students' pre-test and post-test results.

TABLE 1. Pre-Test and Post-Test Results

Type of Test	Average Score	Minimum Score	Maximum Score	Average Improvement
Pre-Test	57.8	45	70	-
Post-Test	74.6	60	85	16.8

To examine the significance of the change between the pre-test and post-test results, a paired sample t-test was employed. The results of the t-test indicated that the improvement in post-test scores compared to pre-test scores was highly significant, with a p-value < 0.05, demonstrating a substantial enhancement in students' conceptual and analytical abilities following the training.

The final session involved a reflection activity in which students shared their learning experiences, effective strategies, and challenges they encountered. Several excerpts from students' reflections are presented below:

- *"I feel more confident in solving logical reasoning questions after participating in this training. I used to feel confused, but now it is easier to understand the question patterns."*
- *"Time management has always been a challenge during exams, but I learned to work more efficiently using the time-management techniques taught in the session."*
- *"Problem-based learning helped me understand difficult concepts better. I can now see the connection between theory and its real-life application."*

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Based on the analysis of the simulated exam results, the findings show a more significant improvement in items focusing on logic and statistics. Most students initially struggled with logical reasoning questions, but after the HOTS-based learning activities, they demonstrated better understanding and were able to answer the questions more accurately. On the other hand, although there was considerable improvement in algebra and geometry items, the greatest challenge remained in understanding abstract concepts and applying formulas in complex problem contexts. Students required more practice and deeper explanations to master advanced problem-solving techniques in these topics.

Overall, the program was successfully implemented and received positive feedback from both participants and the school. Based on the simple pre-test and post-test results, the average score increased from 57.8 to 74.6, indicating a significant improvement in students' conceptual understanding and analytical skills after the training. This program not only improved students' academic readiness for the academic aptitude test but also prepared them for future professional challenges by strengthening HOTS and the application of mathematical problem-solving skills.

Discussion

The results of this community service program indicate that the interactive HOTS-based training model, combined with an academic aptitude test simulation, is effective in improving vocational students' academic readiness. The recorded improvements cover three main dimensions: conceptual understanding of mathematics, problem-solving skills, and students' self-confidence. These findings align with previous research confirming the importance of Problem-Based Learning (PBL) and Higher Order Thinking Skills (HOTS) in vocational education contexts. For example, Sembiring & Napitupulu (2022), in their study on interactive worksheets to enhance HOTS, found that interactive approaches can indeed improve students' higher-order thinking skills, although their application across various learning settings, including community service programs, remains underexplored. This community service activity, which integrates academic test simulations within an interactive learning framework, provides a valuable contribution by applying HOTS in a more concrete real-world context.

Furthermore, the study by Moyo et al. (2022), which examined the use of formative assessments to enhance HOTS, also demonstrated positive potential but did not provide specific insights into how such assessments can be effectively integrated into vocational training or community service initiatives. In this program, the integration of academic test simulations with HOTS-based training offers a more practical and immediate learning context, helping students better prepare for both actual examinations and professional challenges in the workplace.

FIGURE 1. The Process of Delivering Academic Ability Test Material

However, despite the significant improvements recorded in the post-test results, this community service program has several limitations. First, the sample was limited to vocational high school students

https://doi.org/10.35568/abdimas.v9i1.7356

from a single location, which restricts the generalizability of the findings to a broader population. Second, although there was a notable increase in students' analytical skills, further research is needed to examine the long-term sustainability of these skills, particularly in the context of more demanding university entrance examinations. The simulation results also revealed persistent challenges, such as time management and difficulties in understanding algebra and geometry questions. These findings indicate that students still require more intensive practice to master more complex problem-solving techniques in these topics.

Theoretically, the findings of this community service activity reinforce the importance of implementing HOTS-based learning to improve mathematical competence among vocational students. The interactive HOTS-based training model used in this activity supports constructivist theory, which emphasizes the value of direct experience and reflective learning in mathematics education. From a practical standpoint, the results provide a model that can be adopted in mathematics instruction at vocational schools to strengthen conceptual understanding and critical thinking skills. The integration of academic exam simulations in the learning process offers a more applicable and relevant experience, preparing students not only for academic examinations but also for the professional challenges they will encounter in the workplace.

This activity demonstrates that the combination of HOTS-based training and academic exam simulations can generate a significant positive impact on improving the academic readiness of vocational students. The increase in average scores, active student engagement, and positive shifts in attitudes toward mathematics provide strong evidence that this model is effective and can be expanded for wider implementation across vocational schools in Indonesia.

CONCLUSION

Based on the implementation of this community service program, it can be concluded that the HOTS-based mathematics reinforcement program proved effective in improving vocational high school students' readiness for the Academic Ability Test, as evidenced by a significant increase in the average score from 57.8 to 74.6. The program, which integrates interactive approaches, Academic Ability Test simulations, and reflection activities, successfully bridged the gap between practical vocational learning and the conceptual demands of the Academic Ability Test. However, this program also has several limitations, including the limited sample that involved students from only one vocational school, making the findings not yet generalizable to a wider population, as well as the absence of an assessment of the long-term sustainability of the students' improvement. Another limitation lies in the persistent challenges students faced in algebra and geometry topics, which require further instructional depth.

For program sustainability, several strategic recommendations are proposed. For schools, it is recommended to integrate HOTS training modules into the regular mathematics curriculum and to conduct periodic workshops for teachers to strengthen instructional methodologies. For future researchers, it is important to expand the scope of this community service initiative to include a larger number of vocational schools with diverse characteristics, develop specialized materials for algebra and geometry, and conduct longitudinal studies to measure the long-term impact of the program. The sustainability potential of the program can be realized through the development of a "train-the-trainer" model involving trained teachers as facilitators, the formation of inter-school communities of practice for resource sharing, and the creation of digital platforms that allow students to access practice materials and Academic Ability Test simulations independently, thereby ensuring continued program benefits even after direct intervention from the university ends.

https://doi.org/10.35568/abdimas.v9i1.7356

ACKNOWLEGDEMENTS

The authors would like to express their sincere gratitude to SMK Pratama Mulya Karawang for their full cooperation and active participation throughout the implementation of this community service program. Special appreciation is also extended to the teachers and students who enthusiastically engaged in the training and simulation activities, contributing to the success of the program. The authors are deeply thankful to the Institute for Research and Community Service (LPPM) of Universitas Buana Perjuangan Karawang for providing guidance, institutional support, and facilitation throughout the preparation and execution of this activity. Appreciation is also given to all members of the implementation team whose dedication and collaboration ensured the smooth and effective realization of this program. This community service initiative was not only made possible by the collective effort of the team and institutional support, but also by the shared commitment to improving the quality of mathematics education and enhancing the academic readiness of vocational high school students for the Academic Ability Test.

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