(RESEARCH ARTICLE)

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Development of STEM-Based Instructional Materials on Two-Variable Linear Inequalities to Enhance Students Mathematical Competence

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Abstract

This study aimed to develop STEM-based learning devices on two-variable linear inequalities to improve the mathematical abilities of vocational high school students. The research employed the Research and Development (R and D) method using the 4D model proposed by Sivasailam Thiagarajan. The stages included Define, Design, Develop, and Disseminate. The subjects were 26 eleventh-grade students majoring in Digital Business. The developed products consisted of teaching modules, student worksheets (LKPD), and assessment instruments. The validation result showed an average score of 3.25 (valid category). The practicality test indicated a 97% positive response (very practical), while the effectiveness test showed 80% classical mastery (≥ KKM 75). Therefore, the developed STEM-based learning devices are valid, practical, and effective for improving students' mathematical abilities.

Keywords: STEM Education; Learning Devices; Linear Inequalities; Mathematical Ability; 4D Model; Vocational School

1. Introduction

Education in the 21st century emphasizes critical thinking, creativity, collaboration, and communication skills. Trilling and Fadel [1] stated that modern education must integrate information literacy and technology literacy into learning practices. In mathematics education, these competencies are closely related to mathematical ability.

According to the National Council of Teachers of Mathematics [2], mathematical ability includes problem solving, reasoning and proof, communication, connections, and representation. However, students often experience difficulties in algebraic topics such as two-variable linear inequalities due to abstract concepts and limited contextual application.

STEM (Science, Technology, Engineering, and Mathematics) provides an interdisciplinary approach to contextual learning. Bybee [3] emphasized that STEM education integrates real-world problem solving and cross-disciplinary knowledge. Recent studies confirmed that STEM-based learning significantly improves mathematical achievement and critical thinking skills [4,5].

Despite these findings, structured development of STEM-based learning devices for two-variable linear inequalities in vocational education remains limited. Therefore, this study aims to develop and evaluate STEM-based learning devices that meet validity, practicality, and effectiveness criteria.

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2. Material and methods

2.1. Research design

This study used the Research and Development (R&D) method with the 4D model developed by Sivasailam Thiagarajan [6], consisting of:

- Define
- Design
- Develop
- Disseminate

2.2. Participants

The participants were 26 students of grade XI Digital Business at SMKS Muhammadiyah 02 Paleran, Indonesia.

2.3. Instruments

- The instruments included:
- Expert validation sheets
- Student response questionnaires
- Mathematical ability tests

2.4. Data analysis

Validity was measured using a 4-point Likert scale. Practicality was calculated from student response percentages. Effectiveness was determined using classical mastery criteria (≥ 80% students achieving KKM ≥ 75).

3. Results and discussion

3.1. Validity

The validation results showed an average score of 3.25, categorized as valid. The devices fulfilled the criteria of content feasibility, STEM integration, language clarity, and presentation structure. This is consistent with findings indicating that STEM-based learning devices scoring above 3.20 are considered valid [7].

3.2. Practicality

The student response questionnaire indicated a 97% positive response rate (very practical). Students reported that contextual problems and GeoGebra-assisted visualization improved understanding of inequality graphs and solution regions.

3.3. Effectiveness

The classical mastery result reached 80%, meaning 21 out of 26 students achieved scores ≥ 75. This confirms that STEM-based learning effectively improves mathematical problem-solving skills. Similar findings were reported in previous studies showing that STEM integration enhances conceptual understanding and mathematical literacy [5,8].

Overall, the developed learning devices met the criteria of validity, practicality, and effectiveness.

4. Conclusion

The STEM-based learning devices on two-variable linear inequalities developed using the 4D model are:

- Valid (3.25 average score)
- Very practical (97% positive response)
- Effective (80% classical mastery)

Thus, they are suitable for improving mathematical ability in vocational high school students.

Compliance with ethical standards

Disclosure of conflict of interest

The authors wish to declare that none has any interest to disclose.

References

[1] Trilling B, Fadel C. 21st century skills: Learning for life in our times. San Francisco: Jossey-Bass; 2009.

[2] National Council of Teachers of Mathematics. Principles and standards for school mathematics. Reston (VA): NCTM; 2000.

[3] Bybee RW. The case for STEM education: Challenges and opportunities. Arlington (VA): NSTA Press; 2013.

[4] Anwar R, Hidayati N. Implementation of STEM learning to improve students' critical thinking skills. J Pendidik Sains. 2021;9(2):120–128.

[5] Nugroho A, Sari P. Meta-analysis of STEM learning effects on mathematics achievement. Riset Pendidik Mat. 2023;10(2):150–162.

[6] Thiagarajan S, Semmel DS, Semmel MI. Instructional development for training teachers of exceptional children: A sourcebook. Bloomington: Indiana University; 1974.

[7] Lestari D, Rahman A, Putri S. Effectiveness of STEM-based learning devices in improving numeracy literacy. Pendidik Mat Indones. 2022;7(1):45–53.

[8] Pratama Y, Suryani E. The effect of STEM learning on vocational students' mathematics achievement. Inov Pendidik. 2023;5(3):210–218.