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Effectiveness of STEM-Oriented Project-Based Learning Modules in Visual Communication Design to Support Science and Technology Skills in Vocational Education

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Abstract: This study aims to develop and evaluate the effectiveness of a STEM-oriented entrepreneurship-based learning module using a Project-Based Learning (PjBL) model in the Basic Principles of Design and Visual Communication subject at SMK Negeri 2 Guguak. The research used the Research and Development (R&D) method with the 4D model (Define, Design, Develop, Disseminate). Data were collected through observations, expert validations, and pretest-posttest experiments involving teachers and students. The module received high feasibility ratings from media experts (4.87) and material experts (4.89). Practicality tests showed very practical results from both teachers (97.38) and students (87.11). Effectiveness was confirmed through a Paired Samples Test with significant improvements in student learning outcomes (Sig < 0.005; t-value > t-table). In conclusion, the developed module is valid, practical, and effective in improving learning outcomes and integrating STEM-based competencies in vocational education.

Keywords: Learning media; Module; Visual Design and Communication; Project Based Learning

Introduction

Vocational secondary education, particularly in Vocational High Schools (SMK), plays a strategic role in preparing young generations to enter the workforce or become successful entrepreneurs (Firmansyah et al., 2020). One of the key subjects supporting this goal is productive subjects, which focus not only on technical skills but also on fostering entrepreneurial mindsets, such as creativity, innovation, and problem-solving abilities (Supandi, 2022). Through productive subjects, students are expected to face the challenges of the business world and adapt to the dynamic needs of the industry. However, the implementation of productive subjects still faces several challenges, including the lack of maximized entrepreneurial mindset development and the limited use of effective learning models (Adlim et al., 2020).

Innovative approaches like Project-Based Learning (PjBL) offer a solution to these issues. PjBL places students at the center of the learning process by engaging them in research, project development, and problem-solving (Muslim et al., 2020). This model has been proven to enhance skills in planning, designing, and creating innovative products while encouraging critical thinking (Utama et al., 2020). Furthermore, this approach provides real-world learning experiences that better prepare students to adapt to professional environments or create independent business opportunities (Nafilah & Elfizon, 2021).

Observations at SMKN 2 Guguak reveal several challenges in productive learning. The limited application of innovative models like Project-Based

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Learning (PjBL) with an entrepreneurial focus has resulted in relatively low student interest in entrepreneurship (Agustin, 2022). Traditional teaching methods also reduce interaction and student engagement in the learning process. Additionally, students often struggle to complete tasks on time, which hampers their ability to develop practical skills effectively (Jenita et al., 2023). These issues contribute to high unemployment rates among SMKN 2 Guguak graduates.

To address these challenges, the development of a Project-Based Learning (PjBL) teaching module becomes a strategic initiative. This module is designed to guide teachers in implementing project-based learning that emphasizes entrepreneurial skill development. By using this module, students are expected to improve their creative and innovative abilities while building problem-solving mindsets. This approach aims to integrate practical skills with industry needs, preparing students to continue their education, join the workforce, or start their own businesses.

This study aims to answer the research question: "How effective is a STEM-oriented PjBL module in enhancing science and technology-related skills among vocational high school students in the Visual Communication Design subject?"

The novelty of this research lies in integrating STEM principles into a vocational subject (DKV) through a contextual PjBL approach, which has rarely been explored in previous studies.

Method

This study employs the Research and Development (R&D) method, aimed at analyzing needs and subsequently developing instructional media to enhance the clarity of material delivery by teachers (Mesra et al., 2023). According to (Hanafi, 2017), R&D is a research method designed to produce specific products and test their validity and effectiveness in practice. Thus, R&D can be summarized as a method typically used to create specific products while simultaneously evaluating their validity and effectiveness.

A model represents a concept encompassing a framework of interconnected ideas and relationships. In the context of educational research, models serve to link theoretical understanding, providing a representation that aids in acquiring valid, practical, and effective data (Witara et al., 2023). This research adopts the R&D method to develop or refine products, including hardware (e.g., textbooks and learning tools) and software (e.g., applications and instructional videos), ensuring their effectiveness for educational purpose (Sugiyono, 2017).

The study uses the four-D model (Define, Design, Develop, and Disseminate) due to its systematic and structured stages, aligning with the study's background issues (Richey & Klein, 2007). This model facilitates the creation of instructional media that are valid, practical, and effective in enhancing students' learning interest (Zakaria et al., 2023). The illustration of the procedure for developing an entrepreneurship-based module in the Productive subject of the DKV Department at SMK can be described in full as follows:

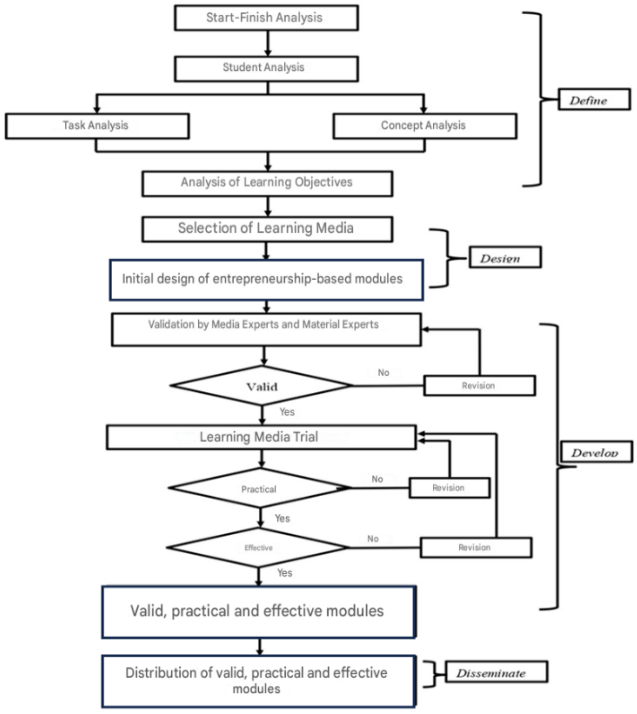

Figure 1. Research Procedures

After validation by experts, product testing was conducted to evaluate the effectiveness of the entrepreneurship-based learning module for grade X DKV students at SMK Negeri 2 Guguak. The trial involved two groups: an experimental group using the module and a control group that did not. he experimental group consisted of 32 students (n = 32), while the control group also consisted of 32 students (n = 32). To measure the improvement in learning outcomes, the normalized gain score (g). The gain score was then categorized based on Hake's classification:

- High: g>0.7g > 0.7g>0.7
- Medium: 0.3≤g≤0.70.3 \leq g \leq 0.70.3≤g≤0.7
- Low: g<0.3g < 0.3g<0.3

The evaluation employed a Pretest-Posttest Control Group Design, comparing student performance before and after using the module to assess its impact on learning outcomes. Validation was carried out by two media experts from the Faculty of Engineering, UNP,

and two productive subject teachers specializing in DKV.

The effectiveness analysis focused on comparing pretest and posttest scores to determine the module's impact. Statistical tests included normality and homogeneity tests to confirm data validity. Data was considered normally distributed if the significance value was greater than or equal to 0.05. A homogeneity test was conducted to verify variance similarity between groups, with data deemed homogeneous if the significance value was greater than or equal to 0.05. An independent sample T-test was used to identify significant differences between the experimental and control groups. The module was considered effective if the experimental group's posttest results significantly exceeded those of the control group, as indicated by a calculated t-value greater than the t-table value.

Result and Discussion

Result

This study aimed to develop an entrepreneurship-based learning module for the subject Basic Principles of Design and Visual Communication (DKV) for grade XII students at SMK Negeri 2 Guguak. The development process used the 4D model, consisting of Define, Design, Development, and Disseminate stages, to ensure the module's validity, practicality, and effectiveness.

1. Define Stage

The Define stage focused on understanding the current learning conditions and identifying the needs for developing an entrepreneurship-based module. Interviews with teachers and students revealed that while the DKV curriculum included topics on market research and commercial opportunities, students struggled to grasp these concepts due to the lack of integrated entrepreneurship-focused learning media. Additionally, although all students owned Android smartphones, these were underutilized in the learning process. As a solution, the research proposed an interactive module accessible through Android devices, aiming to enhance learning flexibility, motivation, and understanding.

2. Design Stage

During the Design stage, the module was structured into several components, each designed to address the learning objectives and improve student engagement. The first component, the cover page, was designed to provide a professional and engaging first impression. It includes the title and essential information about the module while employing visual elements aligned with the themes of entrepreneurship and visual communication. The second component, the general information page, serves as a roadmap for both students and teachers, outlining the planned learning activities and providing clear instructions to navigate the module effectively.

The teaching material page constitutes the core content of the module. This section focuses on the principles of design and visual communication while integrating entrepreneurship concepts such as market research and commercial opportunities. The content is enriched with real-world examples and applications to bridge theory and practice. Furthermore, the module includes a student worksheet (LKPD), which is designed to evaluate students' understanding and application of the concepts they have learned. The tasks encourage critical thinking, creativity, and entrepreneurial problem-solving.

Lastly, the assessment rubric provides a comprehensive framework for evaluating students' knowledge, creativity, and presentation skills. This rubric ensures alignment with the learning objectives and maintains transparency in grading. Each component in the module was carefully developed to foster active engagement and independent learning, while also equipping students with practical skills applicable to real-world contexts.

Table 1. Structure of the Entrepreneurship-Based Learning Module

Component	Description
Cover Page	Displays the title and general information about the module.
General Information	Provides an overview of learning activities and their sequence.
Teaching Materials	Contains detailed content on design principles and entrepreneurship.
Student Worksheets (LKPD)	Includes exercises and projects for assessing understanding.
Assessment Rubric	Outlines criteria for evaluating students' knowledge and creativity.

Each component was designed to encourage students to actively engage with the learning material while fostering independent learning and problem-solving skills. The focus on entrepreneurship ensures that students not only understand theoretical concepts but also gain practical knowledge relevant to real-world applications.

3. Development Stage

In the Development stage, the module was evaluated by media and material experts, followed by testing its practicality and effectiveness with teachers and students. The validation process involved assessments by media and material experts to ensure the

module met educational standards. The results showed that the module was well designed and aligned with the required educational objectives, making it suitable for implementation in the classroom.

Table 2. Media Validation Results

Aspect Assessed	Average Score	Category
Cover	0.80	Valid
Introduction Page	0.88	Valid
Middle Section	0.86	Valid
Closing Section	0.83	Valid
Average	0.84	Valid

The media validation results indicate that all assessed aspects, including the cover, introduction page, middle section, and closing section, were categorized as "Valid," with average scores ranging from 0.80 to 0.88. The overall average score of 0.84 confirms that the module's media design meets the necessary standards for implementation.

Table 3. Material Validation Results

Assessment Aspect	Average Score	Category
Material Relevance	0.86	Valid
Design Display Quality	0.94	Valid
Benefits	0.97	Valid
Average	0.92	Valid

The table above presents the expert validity results for the material, including three key aspects: material relevance, design display quality, and benefits. The average score for each aspect is above 0.85, indicating that the material is considered valid in all areas assessed. The highest score is given to the benefits aspect, with a score of 0.97, reflecting strong approval. The overall average score of 0.92 further confirms that the material is deemed valid for use.

The module's effectiveness was evaluated using a Pretest-Posttest Control Group Design. In the effectiveness test, student learning outcomes were measured based on the gain score, which was obtained by comparing pretest and posttest scores. The analysis revealed a gain score of 52.32, categorized as "Moderate," indicating an improvement in learning outcomes due to the use of the entrepreneurship-based module.

Table 4. Normality Test Results Using Liliefors Test

Class	L-statistic	L-table	Conclusion
Experimental	Pre-test 0.139	0.157	Normal
	Post-test 0.150	0.157	Normal
Control	Pre-test 0.145	0.157	Normal
	Post-test 0.121	0.157	Normal

The normality test conducted using the Liliefors test shows that the data from both groups (experimental and control) are normally distributed. Meanwhile, the homogeneity test using Levene's Test yielded a significance value of 0.077, which is greater than 0.05, indicating that the variances of the data from both groups are homogeneous.

Table 5. Homogeneity test using Levene's Test

Class	Pre-test	Post-test
Experimental	52.81	77.50
Control	37.97	63.44

To test for significant differences between the posttest learning outcomes of the experimental and control classes, an independent sample t-test was used. The test results showed a significance value of 0.001 (less than 0.05), indicating a significant difference between the two groups. Furthermore, the t-value (3.734) was greater than the t-table value (2.040), confirming that the alternative hypothesis is accepted, i.e., the entrepreneurship-based module effectively improves student learning outcomes in the Basic Principles of Design and Visual Communication subject at SMK Negeri 2 Kecamatan Guguak.

Table 5. Paired Samples Test Results

Pair	Mean-Difference	t-value	df	Sig.(2-tailed)
Pre-test (Experiment) - Pre-test (Control)	14.844	4.013	31	0.000
Post-test (Experiment) - Post-test (Control)	14.063	3.734	31	0.001

4. Disseminate Stage

The module, after being validated and proven effective, was distributed to teachers and students via an Android-compatible link. This stage aimed to ensure broader adoption of the module in similar classes or schools. Feedback highlighted the module's potential to enhance learning quality and student outcomes, particularly in entrepreneurship-focused subjects.

This comprehensive process demonstrates that the entrepreneurship-based module not only meets educational standards but also provides practical benefits in improving students' understanding and application of design and entrepreneurship concepts.

Discussion

The validity of the entrepreneurship-based module was assessed through expert evaluations from both media and subject matter specialists. The media validation score was 0.84, categorized as "valid," indicating that the learning media developed is

appropriate for use in teaching. Meanwhile, the subject matter validation score was 0.92, categorized as "valid," showing that the content of the module met the standards set by the subject matter experts. These findings indicate that the module is ready for implementation in the classroom, as it meets the necessary criteria for both content accuracy and instructional quality.

The validity assessment aligns with the results of previous studies, such as those conducted by (Rizal, 2023), which also categorized similar learning media as "highly feasible." This suggests that the design and content of the entrepreneurship-based module can effectively engage students and facilitate learning. The validation process confirms that the module is not only academically sound but also motivating and engaging for students. The positive feedback from both media and subject matter validators underscores the module's suitability for classroom and independent learning environments.

The practicality of the module was evaluated based on feedback from teachers and students regarding its usability and ease of implementation. The results showed that the average score for the teacher's evaluation was 97.88%, categorized as "very practical," indicating that the module is easy for educators to use and integrate into their teaching practices. In addition, the student evaluation had an average score of 89.00%, categorized as "very practical," suggesting that students found the module engaging and user-friendly. This feedback highlights that the module is both practical for the teacher and enjoyable for the students, making it an effective tool for learning.

These findings are consistent with previous research by (Betty et al., 2023), which found that practical learning media contributed to better teaching outcomes. Furthermore, the results also align with (Riza & Chisbiyah, 2024) assertion that educational media must be straightforward and easy to use. A practical module allows teachers to focus more on teaching and less on troubleshooting, thereby improving instructional efficiency (Riza & Chisbiyah, 2024). The ease of use also allows for better student engagement, as they can quickly become familiar with the material. Thus, the practicality of the entrepreneurship-based module is one of its key strengths, making it a viable tool for enhancing the learning experience.

The effectiveness of the entrepreneurship-based module was tested through a pretest-posttest design, comparing the learning outcomes of students in both the experimental group (using the module) and the control group (receiving conventional teaching). The results of the t-test analysis revealed a significant difference between the two groups, with a p-value of 0.001, indicating that the module had a positive effect on student learning. The t-value of 3.734 was greater than the t-table value of 2.040, further confirming the statistical significance of the improvement in the experimental group's posttest scores.

This finding is supported by previous studies, such as those by (Malik, 2024), which showed that entrepreneurship-based modules significantly enhanced student learning. The module was found to not only improve learning outcomes but also encourage student engagement and positive responses. The results demonstrate that the module is effective in achieving the desired learning objectives for the subject matter. The effectiveness of the entrepreneurship-based module reflects its potential as a tool that can foster better learning experiences, increase student motivation, and provide a deeper understanding of the subject matter (Adlim et al., 2020).

The findings of this study align with previous research conducted by (Malik, 2024), which showed that the implementation of Project-Based Learning in entrepreneurship subjects improved both learning outcomes and student engagement in vocational settings. Similarly, (Adlim et al., 2020) also found that STEM-oriented PjBL tools enhanced student competencies in light vehicle engine maintenance at vocational schools, highlighting the adaptability of PjBL across different vocational fields.

Compared to these studies, this research contributes by integrating STEM-oriented PjBL into Visual Communication Design (DKV)—a field that is typically considered non-IPA. This integration shows that even design-based subjects can embed scientific reasoning, technological applications, and engineering problem-solving through well-structured learning modules. Therefore, this study strengthens the evidence that PjBL with STEM emphasis can be effectively implemented in diverse vocational subjects, enhancing both technical and scientific skills among students.

Conclusion

Based on the research findings and discussion, the development of entrepreneurship-based learning modules for the subject of Basic Principles of Design and Visual Communication in Grade XI of the Visual Communication Design (DKV) Department at SMK Negeri 2 Kecamatan Guguak has proven to be effective. The module development process followed the 4D research model (Define, Design, Develop, Disseminate), with validation results from material experts scoring 0.92 and media experts scoring 0.84, both categorized as "valid." In terms of practicality, the module received scores of 97.88 from teachers and 89.00 from students,

both categorized as "very practical." The module's effectiveness was evidenced by a gain score of 52.53, indicating a medium improvement in learning outcomes. Furthermore, the t-test (Paired Samples Test) analysis showed a significant influence on learning outcomes between the experimental and control groups. Normality and homogeneity tests also confirmed that the data were normally distributed and homogeneous, supporting the conclusion that this entrepreneurship-based learning module is feasible and effective for use in teaching.

Given its proven validity, practicality, and effectiveness, it is recommended that this module be implemented more broadly across other vocational high schools (SMKs) with similar expertise programs. Policymakers and school administrators are encouraged to integrate entrepreneurship-based learning modules into the curriculum as part of efforts to strengthen entrepreneurial mindsets and prepare students for the demands of the creative industry. Additionally, training and workshops for teachers should be provided to ensure successful adoption and adaptation of the module to various local contexts and student needs.

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The author declares no conflict of interest.

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