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Development of a Mathematics Student Worksheet Using SketchUp Based on a Project-Based Learning Approach

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Abstract: This research focuses on the development of a SketchUp-based student worksheet using a project-based learning approach to support geometry learning in junior high school. The study responds to the lack of visual media in conventional mathematics instruction, particularly in representing three-dimensional objects. The development process followed the 4D model: Define, Design, Develop, and Disseminate. At the Define stage, a needs analysis revealed students' difficulties in spatial reasoning and their preference for visual learning. SketchUp was selected for its capability to model 3D objects interactively. The product was validated by two experts, resulting in an average score of 89% for content and 87% for media, both categorized as "very feasible." A limited trial involving 18 ninth-grade students showed an average feasibility score of 80.3%, indicating positive student responses. Although some improvements are needed in the clarity of instructions, the integration of SketchUp and project-based learning shows potential to enhance student engagement and learning experiences in geometry. The study supports the development of innovative, curriculum-aligned digital learning media.

Keywords: digital learning media; geometry; mathematics education; project-based learning; sketchup.

INTRODUCTION

The advancement of technology in the era of globalization has had a significant impact on the field of education (Baikuna et al., 2024). Global demands require educational institutions to adapt to technological developments in order to improve the quality of learning (Nurillahwaty, 2021). Technology has transformed the way interaction and learning occur in classrooms, enabling the development of skills relevant to the demands of the digital era (Iskandar et al., 2023). Therefore, the integration of technology in education has become essential to prepare students for future challenges.

Instructional media is an essential component of the learning process, serving as a tool to deliver material effectively and engagingly (Nurfadhillah et al., 2021; Wulandari et al., 2023). It facilitates interaction between educators and students, making the learning process more interactive, efficient, and engaging (Ramdani et al., 2021). In addition, instructional media supports the delivery of standardized content and enhances the quality of students' learning outcomes (Nurmalia et al., 2022; Safira, 2020; Ilham et al., 2023).

One of the instructional media that can be developed in learning is technology-based media such as SketchUp (Adila & HS, 2022). SketchUp is a software application used to represent three-dimensional shapes through computer-based modeling (Harianti et al., 2021; Lase, 2021; Simamora, 2022). Several previous studies have shown that the use of SketchUp in learning can increase students' interest in geometry, as demonstrated in studies by (Abdullah et al., 2022; Nishiguchi, 2025), which found that interactive visual approaches through 3D modeling not only make learning more engaging but also promote active student participation in the learning process. These findings highlight the significant potential of SketchUp to support teaching and learning, especially in subjects that require strong visualization.

One of the learning models that can be used to implement SketchUp is Project-Based Learning (PjBL) (DelPiano, 2021; Ferreira, 2021; Huang et al., 2023). Project-based learning

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is an instructional approach that emphasizes the completion of real-world projects to develop students' skills (Yuniarti, 2021; Nurhamidah & Nurachadijat, 2023; Zulkarnaen et al., 2023). Key characteristics of PjBL include a focus on real-life problems, student-centered learning, teamwork, and the production of concrete outcomes or solutions. Its benefits include enhancing students' critical thinking, creativity, problem-solving abilities, motivation to learn, and social skills through collaboration (Anisa, 2022; Fatiati, 2023; Ansya & Salsabilla, 2024, 2024; Aji et al., 2024; Hanifah & Zulfikar, 2024).

The selection of the PjBL model in this study is based on its alignment with the learning objectives, which aim to encourage students to produce a final product as an outcome of the learning process, to be presented in front of the class. In this context, SketchUp serves as a digital tool to support the realization of these products in the form of 3D geometric models. Therefore, PjBL provides a learning framework that not only supports the natural integration of SketchUp but also guides students toward more meaningful, applicable learning experiences aligned with the Merdeka Curriculum, which emphasizes competency achievement through real-world projects.

Although prior studies have shown that SketchUp can enhance students' interest in geometry (Abdullah et al., 2022; Nishiguchi, 2025), this study focuses on developing a SketchUp-based student worksheet (LKPD) that serves not only as a visual aid but also as an integral component of the PjBL model, requiring students to create and present digital products. Thus, this research does not merely address learning interest but also explicitly emphasizes the enhancement of students' collaboration, creativity, and responsibility within the project-based learning context. Based on this rationale, the researchers aim to develop a SketchUp-based LKPD using the PjBL approach for teaching mathematics, specifically the topic of solid geometry at the junior high school level

METHODS

This research was conducted at a junior high school located in Central Kalimantan. The implementation took place during the school's quiet week, a period between regular lessons and final examinations, which allowed limited trials to be conducted without disrupting ongoing classroom activities. The timing also aligned with the geometry topic being taught to ninth-grade students, ensuring that the product tested was relevant to the current curriculum and learning context.

This study employed a research and development (R&D) method by adopting the 4D model (Define, Design, Develop, Disseminate) developed by (Thiagarajan, 1974). The 4D model was selected due to its focus on iterative product validation and adaptability to field needs, in contrast to the more linear ADDIE model. Additionally, the 4D model provides a systematic framework for developing instructional products, particularly technology-assisted student worksheets (LKPD) (Khoiriyah et al., 2024). The following is a diagram of the 4D model by (Thiagarajan, 1974).

Based on Figure 1, the 4D model consists of four main stages: Define, Design, Develop, and Disseminate. Define stage, the research focused on identifying and defining the needs within the learning process and collecting relevant information related to the product to be developed. The initial analysis revealed that students had difficulty understanding three-dimensional geometric concepts when presented abstractly, thus requiring media that could represent these concepts visually and concretely. After evaluating several alternatives, SketchUp was chosen because of its ability to model three-dimensional shapes interactively. Furthermore, an analysis of student characteristics showed that they tended to feel bored with conventional teaching methods but became more motivated and engaged when visual media were used. To ensure its relevance, the development of the student worksheet (LKPD) was

aligned with the Merdeka Curriculum. From the analysis of media already used in schools, it was found that although students were familiar with technology, SketchUp had never been implemented before, making it a highly promising tool for enhancing mathematics learning.

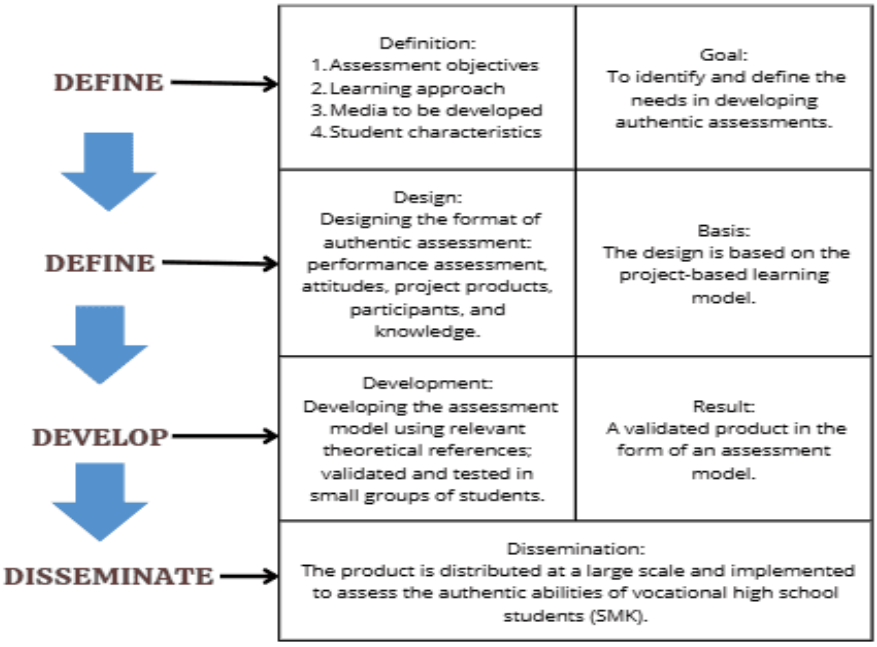

Figure 1. The 4D Model Diagram

Design stage, which aimed to create a SketchUp-based student worksheet (LKPD) on solid geometry. Based on the results of the definition stage, the researcher designed an instructional medium in the form of an LKPD supported by visual design using Canva. SketchUp was selected for its capability to model three-dimensional objects relevant to solid geometry, while Canva was used to organize the worksheet layout to make it more attractive, structured, and accessible for students. The LKPD components included project guidelines, visual tutorials, and worksheet activities. Examples of using SketchUp to construct cubes, rectangular prisms, prisms, and other three-dimensional shapes were incorporated into the project-based learning activities.

Develop stage, the designed LKPD product was validated by experts to ensure its feasibility. The validation involved two experts: a media expert and a content expert, both lecturers from the Mathematics Education Study Program with relevant expertise. The validation instrument used a Likert scale (Likert, 1932), modified from (Robinson, 2024), with categories ranging from very good (5), good (4), fair (3), poor (2), to very poor (1). The validation data were analyzed using descriptive quantitative methods with percentage formulas. The results were then classified according to the feasibility criteria proposed by (Djakadana et al., 2022): very feasible (81–100%), feasible (61–80%), fairly feasible (41–60%), and so on.

Disseminate stage, which involved testing the product on the research subjects. This began with preliminary observations in three junior high schools in Central Kalimantan. From these observations, one school was chosen as the trial site because its students were already accustomed to using technology in the learning process. The trial subjects consisted of 18 ninth-grade students in the second semester. Data were collected using a student response questionnaire regarding the SketchUp-based LKPD. The questionnaire was structured on a five-point Likert scale: Strongly Agree (5), Agree (4), Neutral (3), Disagree (2), and Strongly Disagree (1). The purpose of this questionnaire was to evaluate students' perceptions of the

clarity, usefulness, and attractiveness of the developed LKPD. The results were analyzed using descriptive statistics in percentage form and categorized according to the criteria from (Djakadana et al., 2022): 81–100% (Very Good), 61–80% (Good), 41–60% (Fair), and so on.

RESULTS AND DISCUSSION

Based on the initial analysis conducted during the define stage, a major issue in teaching three-dimensional geometry was identified: students demonstrated low levels of understanding due to the continued reliance on conventional instructional methods that lacked visual support. As a result, technology-based media such as 3D modeling software were seen as promising solutions that had not yet been optimally utilized in the learning process (Hidayat et al., 2025). An analysis of student characteristics revealed a strong preference for visual and interactive media. This aligns with the traits of Generation Alpha, who are naturally more responsive to digital and visually driven learning environments (Gunawan et al., 2024; Urba et al., 2024). However, most students were not yet familiar with 3D modeling software like SketchUp, indicating the need for structured guidance to support its use in the classroom (Jacobs, 2022).

In the design stage, the researcher selected SketchUp as the primary medium for modeling solid geometry due to its ability to represent geometric objects realistically and in manipulable three-dimensional forms. SketchUp allows students to build, rotate, and explore geometric shapes directly, thereby reinforcing both conceptual understanding and spatial reasoning. Its use is consistent with the principles of the Merdeka Curriculum, which emphasizes contextual, participatory, and project-based learning (Andriani et al., 2025; Ilter, 2014; Simbolon & Koeswanti, 2020; Suryaningsih et al., 2022; Wijnia et al., 2024).

In addition, Canva was used as a visual design tool to create a visually appealing, well-structured, and communicative layout for the student worksheet (LKPD). Canva was chosen for its user-friendly interface and its ability to organize visual elements clearly, helping to improve both readability and the visual appeal of the worksheet. An aesthetically pleasing and accessible worksheet is expected to enhance student engagement and support comprehension of the learning material (Meka et al., 2024; Musdalifah et al., 2024; Nureva, 2023; Rahmah et al., 2023; Said et al., 2023; Saputra & Junaidi, n.d.).

The developed LKPD consists of several key components. The cover includes the title, author information, institutional affiliation, and relevant logos. The usage instructions section provides clear guidance for both teachers and students on how to use the worksheet effectively. The learning objectives are formulated based on the Merdeka Curriculum module, with a focus on developing students' spatial analysis skills. To support both digital and visual understanding, the LKPD includes learning video links sourced from YouTube that introduce students to the basic use of SketchUp. The worksheet also presents critical thinking questions related to the functions and applications of SketchUp in modeling geometric shapes.

The core project activity involves students working in groups to design three-dimensional geometric models digitally using SketchUp. Students collaboratively organize their project timelines and prepare the final products for class presentations. This activity is designed to foster spatial visualization, teamwork, and mathematical communication skills. Following the completion of the project, a reflection section is provided for students to evaluate their learning experiences. A glossary is also included to explain important terms, both in mathematics and in technical use of SketchUp, such as rectangle and push/pull. Finally, a bibliography lists all the references used in developing the LKPD, including textbooks, scholarly articles, and digital sources.

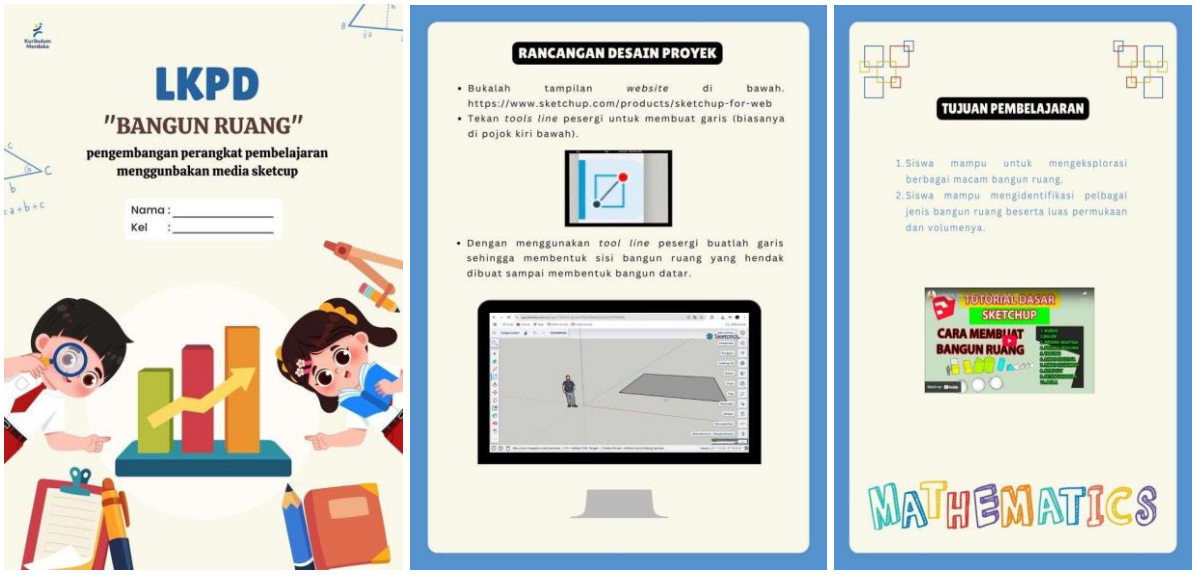

Figure 2. LKPD Prototype

In the Develop stage, after the prototype of the student worksheet (LKPD) was designed and developed, validation was conducted by two experts: a content expert and a media expert. The results of the validation are presented in Table 1 and Table 2.

Table 1. Content Expert Validation Results

Assessment Aspect	Percentage	Classification
Alignment with curriculum	89%	Very Feasible
Presentation	85%	Very Feasible
Language Use	88%	Very Feasible
Average	89%	Very Feasible

Table 2. Material Expert Validation Results

Assessment Aspect	Percentage	Classification
Visual Design	90%	Very Feasible
Usability	85%	Very Feasible
Interactivity	86%	Very Feasible
Content Alignment	88%	Very Feasible
Average	87%	Very Feasible

Although the validation results indicated that the product was categorized as very feasible, the validator provided several suggestions for revision to improve the quality of the product before granting full approval. A summary of their feedback is presented in Table 3.

Table 3. Summary of Expert Suggestions

Validator	Suggested Improvements
Content Expert	- Use consistent mathematical and technical terms between the material and the project instructions.
Media Expert	- Include instructions or tutorials on using SketchUp in the form of a video or QR code. - Ensure text contrast is high enough to remain legible when placed over 3D elements.

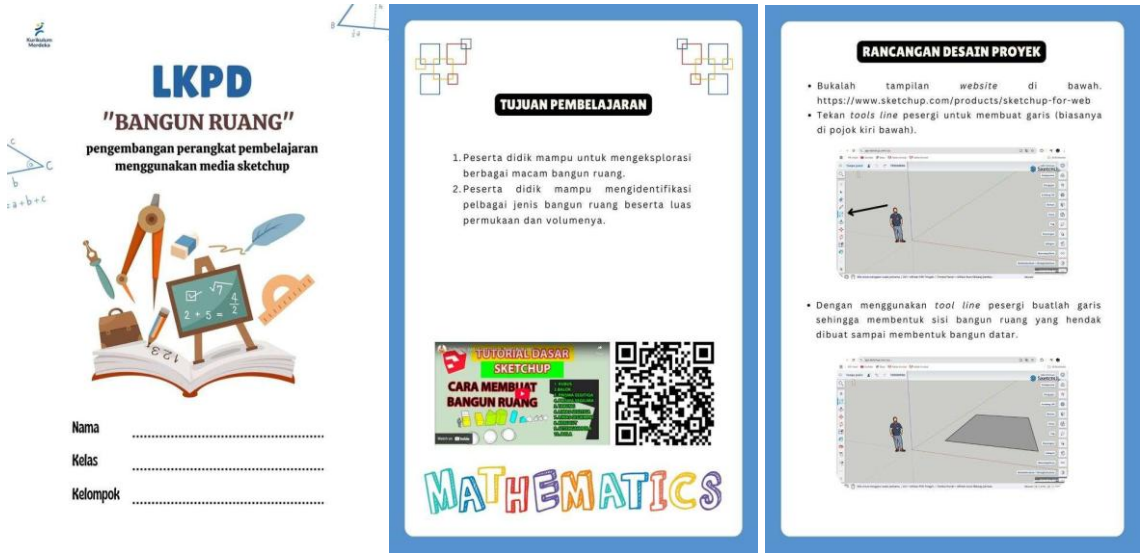

Figure 3. The LKPD Prototype After Revision

After being validated by experts, the LKPD using SketchUp based on the Project-Based Learning approach was implemented at a junior high school located in Central Kalimantan. Students were asked to complete a response questionnaire, and the results are summarized in Table 4.

Table 4. Limited Trial Results

Assessment Indicator	Percentage	Classification
Students agreed that the LKPD helped them understand 3D shapes.	80%	Very Good
Students found the usage instructions clear.	75%	Good
Students were interested in the 3D SketchUp visualization.	86%	Very Good
Average	80.3%	Very Good

The results of this study indicate that the SketchUp-based student worksheet (LKPD) using the Project-Based Learning (PjBL) approach has achieved an adequate level of feasibility, with a score of 80.3%, which falls into the "Very Good" category according to the validation criteria. This finding aligns with previous research by (Kusuma & Suryaman, 2022), which achieved a 91% feasibility score, and is further supported by global trends in the integration of digital tools in geometry learning (Juandi & Fatimah, 2024; Mahmudah et al., 2024; Zafrullah et al., 2024). Overall, the developed LKPD is considered suitable for use as a learning medium, particularly when supported by teacher training and further refinement of content.

In addition to expert validation and student responses, the findings also suggest that implementing the SketchUp-based LKPD within a Project-Based Learning framework effectively facilitates active student engagement. This is consistent with constructivist learning theory proposed by Piaget and Vygotsky, which emphasizes that meaningful learning occurs when students actively construct knowledge through visual interaction with their environment and collaboration with peers (Astiti et al., 2024; Azzahra et al., 2025; Bhattacharjee, 2015; Casfian et al., 2024; Kalpana, 2014; Nurhasnah et al., 2024; Saleem et al., 2021, 2021; Zajda, 2021).

Furthermore, the PjBL approach has proven effective in developing 21st-century skills such as critical thinking, communication, and collaboration. These results are supported by prior studies (Hadiyanti et al., 2021; HS, 2025), which show that integrating PjBL with digital media creates meaningful and contextual learning experiences. In this study, the project activity involving the creation of 3D geometric models provides students with opportunities to engage in active learning, solve real-world problems, and confidently present their work.

From a visual and aesthetic perspective, the use of Canva to support the visual design of the LKPD also contributed positively to the student learning experience. Based on the media validation results, the aspects of visual design and interactivity received high scores, namely 90% and 86%, respectively. These findings are reinforced by studies oleh (Gunawan et al., 2024; Urba et al., 2024) stating that attractive and easy-to-understand visual displays can significantly increase student motivation, especially among digital-native learners such as Generation Alpha, who are accustomed to interactive media.

Finally, the results of this study provide a strong foundation for the development of visual, technology-based learning media within the context of the Merdeka Curriculum, which emphasizes contextual, differentiated, and student-centered learning. However, despite the promising results, this study has several limitations. The product was only tested on a small group of 18 students in a single school, which limits the generalizability of the findings. Additionally, the effectiveness of the SketchUp-based LKPD in improving students' learning outcomes was not measured through pre- and post-tests, but only through expert validation and student perceptions. Furthermore, some students required more time and support to fully understand the features of the SketchUp software, indicating the need for stronger scaffolding in the instructional design. Further research is recommended to examine the effectiveness of the LKPD on a broader scale, such as through trials involving larger and more diverse student populations, or by comparing learning outcomes between experimental and control groups.

CONCLUSION

Based on the results of the limited trial, the SketchUp-based Student Worksheet (LKPD) using the Project-Based Learning (PjBL) model was deemed suitable for use in the learning process, with a feasibility score of 80.3%. However, several aspects still require improvement, particularly in the clarity of the usage instructions and the enhancement of students' independent exploration activities. Future research is recommended to conduct broader trials involving a larger and more diverse sample of students. Comparative studies between experimental and control groups could also be conducted to evaluate the actual impact of the developed LKPD on student learning outcomes. In addition, integrating teacher training modules on SketchUp use may enhance the overall effectiveness and sustainability of the implementation in classroom settings.

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