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Development of Mathematics Learning Tools with Project-Based Learning for The Enhancement of Students' Social Skills and Cognitive Learning Outcomes

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Abstract: *Learning tools have a very important role in the learning process. Good learning tools make it easier for teachers to assist in the process of facilitating student learning. The aim of this research is to produce project-based mathematics learning tools that are valid, efficient and effective for improving students' social skills and cognitive learning outcomes. The type of research that will be used in this research is Development Research. The development model used is a development model adapted from the 4D development model (Define, Design, Develop and Disseminate). The data collection instruments used include device validation sheets, teacher and student response questionnaires, student social skills observation sheets and cognitive ability evaluation test sheets. The research results obtained: the results of device validation, the average score reached 4.2 with a very valid category; The average percentage of students' social skills scores reached 89.2% in the very good category; classical completeness reached 82% of students achieving a complete score; and teacher and student response data reached 4.2 to 93.3% which is in the very good category. Thus, it can be concluded that project-based mathematics learning tools are valid, efficient and effective for improving students' social skills and cognitive learning outcomes in statistics material.*

Keywords*: learning tools, project-based learning, social skills, cognitive learning outcomes*

Abstrak: Perangkat pembelajaran memiliki peranan yang sangat penting dalam dalam proses pembelajaran. Perangkat pembelajaran yang baik mempermudah guru dalam membantu proses fasilitasi pembelajaran siswa. Tujuan penelitian ini adalah untuk menghasilkan perangkat pembelajaran matematika berbasis proyek yang valid, efisien, dan efektif untuk meningkatkan keterampilan social dan hasil belajar kognitif siswa. Jenis penelitian yang akan digunakan dalam penelitian ini adalah Penelitian Pengembangan. Model pengembangan yang digunakan yaitu model pengembangan yang diadaptasi dari model pengembangan 4D (*Define, Design, Develop dan Disseminate*). Instrumen pengumpulan data yang digunakan meliputi lembar validasi perangkat, angket tanggapan guru dan siswa, Lembar Observasi keterampilan social siswa dan lembar tes evaluasi kemampuan kognitif. Hasil penelitian diperoleh: hasil validasi perangkat rata-rata scor mencapai 4.2 dengan kategori kategori sangat valid; rata rata persentasi scor keterampilan social siswa mencapai 89,2% dengan kategori sangat baik; ketuntasan klasikal mencapai 82% siswa mencapai skor tuntas; dan data respon guru dan siswa mencapai 4,2 mencapai 93,3% yang berada pada kategori sangat baik. Dengan demikian dapat disimpulkan bahwa perangkat pembelajaran matematika berbasis proyek valid, efisien, dan efektif untuk meningkatkan keterampilan social dan hasil belajar kognitif siswa pada materi statistika.

Kata kunci: perangkat pembelajaran, pembelajaran berbasis proyek, keterampilan social, hasil belajar kognitif

INTRODUCTION

Learning tools have a very important role in the learning process. Good learning tools make it easier for teachers to assist in the process of facilitating student learning.

Learning tools help teachers carry out the learning process in a systematic, patterned manner, directing students in the process of developing concepts. If teachers do not prepare learning tools before learning, teachers often lose direction and are confused in the middle of the process. Especially in the mathematics learning process.

Mathematics is known as an abstract science, which can be seen as structuring patterns, systematic, critical, logical, careful and consistent thinking (Ansjar & Sembiring, 2001; Masjudin et al., 2020). The characteristics of mathematics are abstract and the mathematical material is arranged hierarchically, requiring teachers to design learning tools optimally. In designing learning tools, teachers are challenged to design detailed activities that involve maximum student potential and interaction

However, the findings obtained by researchers in the field are that the learning tools designed by mathematics teachers often do not develop social interaction between teachers and students or between students and students. The impact on learning, interaction and communication between teachers and students tends to be monotonous and one-way and there is no good social communication between students. Another impact is that outside of learning, the design of these learning tools raises social problems in society, such as mathematics students who are often characterized as lacking the ability to communicate verbally. Apart from that, if students are not trained to interact, it will be possible for them to show disrespect for other people, not listen to opinions or complaints from other people, not want to give or receive feedback, and not want to give or accept criticism, as well as acting not according to the norms and rules set by them. applies.

The field of mathematics education is increasingly paying attention to the development of learning tools that use the project-based learning (PJBL) approach, attracting the attention of researchers because of its potential benefits. Recent studies highlight the positive impact of project/problem based learning on improving students' mathematical problem solving abilities (Fitria et al., 2020). In addition, PJBL has been proven to be effective in facilitating interdisciplinary learning, forming 21st century skills, and increasing students' scientific literacy (Hakim et al., 2019). In various academic disciplines, including biotechnology subjects, PJBL has played an important role in promoting effective learning by actively involving students in critical thinking, collaboration, and problem solving (Movahedzadeh et al., 2012).

Therefore, it is very important to develop a representative learning tool to improve students' social skills and cognitive abilities. One of them is by developing mathematics learning tools with project based learning. The project-based learning model (Project Based Learning) is a learning model that can be used by teachers so that automatically teachers also use a scientific approach in their learning.(Maryati, 2018). With Project Based Learning (PjBL) students are actively involved in an activity (project) that produces a product. Student involvement starts from planning, designing, implementing and reporting the results of activities in the form of products and implementation reports (National et al., 2019). Thus, in carrying out the project, students will be actively involved, interacting to complete the project. So that social interaction will be built into

learning. Learning with this project is also one of the strategies that teachers can use to optimize mathematical problem solving abilities

Although the benefits of PJBL in mathematics education are recognized, there are still challenges in optimizing students' cognitive abilities and social skills. Academic literacy in mathematics is a key factor influencing cognitive development, providing a comprehensive view of mathematical skills through understanding mathematical concepts and discussions (Moschkovich, 2015). Additionally, while the incorporation of gamification elements has shown improvements in collaborative problem-solving skills and social engagement (Pei & Harun, 2023), it is necessary to explore how these elements can be integrated with PJBL in mathematics learning tools.

The urgency of this research lies in overcoming the gaps that exist in mathematics education today. The literature shows that academic literacy, and interdisciplinary approaches play an important role in students' holistic development, thus requiring a thorough examination regarding their integration with PJBL. By understanding the interaction of these elements, educators and researchers can contribute to improving students' cognitive abilities and social skills, thereby preparing them for the demands of the 21st century.Implementation of a project-based learning model will have a positive impact on cognitive skills and caring attitudes towards the environment (Hakim et al., 2019). This shows that PJBL not only improves mathematics skills, but also prepares students with relevant skills for the 21st century.

Although there is sufficient evidence to support the positive impact of PJBL and mathematics learning tools, there is a clear gap in the literature regarding the specific integration of academic literacy, and interdisciplinary approaches in the context of PJBL in mathematics education. This research aims to fill this gap by exploring how these elements can be integrated with PJBL, creating a more robust framework for the development of students' cognitive and social abilities.

This research brings novelty not only by focusing on developing mathematics learning tools with PJBL, but also by strategically integrating academic literacy, gamification, and interdisciplinary approaches. The synthesis of these elements aims to provide a holistic educational experience, not only enhancing mathematical proficiency but also establishing important social skills and preparing students to face the complexities of the modern world. By exploring unexplored territory, this research aims to provide innovative insights into existing knowledge in mathematics education.

The aim of this research is to produce project-based mathematics learning tools that are valid, efficient and effective for improving students' social skills and cognitive learning outcomes

METHOD

The type of research that used in this research is Development Research. According to Borg and Gall (in Setyosari, 2013: 222), development research is a strategy for developing an educational product. According to Seels & Richey (in Setyosari, 2013:223) research and development is "Opposed to simple instructional development, has been

defined as the systematic study of designing, developing and evaluating instructional programs, processes and products that must meet the criteria of internal consistency and effectiveness. ” Based on this description, development research, as distinguished from simple learning development, is defined as a systematic study to design, develop and evaluate programs, processes and learning outcomes that must meet the criteria for internal consistency and effectiveness.

The development model used is a development model adapted from the 4D development model. The stages of the 4D development model include the Define stage, Design stage, Develop stage and Disseminate stage.

Research instruments and data collection techniques in research are three ways, namely:

1. Providing device validation sheets
   Learning device validation sheets were given to three validators, namely expert validators with the criteria of material experts, media and design experts, and education experts. The validator will provide an assessment of the device being developed.
2. Providing teacher and student response questionnaires
   Teacher response questionnaires are given to teachers and students who carry out learning with learning tools
3. Providing observation sheets on students' social skills
   An Observation Sheet is given to the observer. The observer will be tasked with providing assessments and information on the observation sheet regarding students' social interactions. Observation activities were carried out by 2 trained observers.
4. Giving cognitive ability evaluation tests
   Question sheets are given to students to obtain data on students' cognitive learning outcomes

RESULTS AND DISCUSSION

This research uses the Four-D Mode model which includes the Define stage, Design stage, Develop stage and Disseminate stage. This research focuses on developing project-based mathematics learning tools as an effort to improve students' social skills and learning outcomes. The description of the research results is as follows:

1. Define Stage Results

The product developed is a project-based mathematics learning tool. At this define stage, the activities carried out at this stage are establishing and defining learning conditions. This stage is carried out by analyzing the objectives and limitations of the subject matter for which the tool will be developed. This stage includes curriculum analysis, student analysis, material analysis, and formulating learning objectives.

The results obtained at this stage are the emergence of learning indicators for which tools will be developed. The material that will be developed in this research is statistical material regarding placement size. The placement size is divided into three parts, namely

quartiles, percentiles and deciles. However, in this study the researcher will discuss material regarding quartiles, both single data quartiles and group data quartiles.

2. Design Stage.

At the design stage there isa number ofThe stages of activities carried out are, Constructing Criterion-Test, Media Selection, Format Selection, Main Design. The output produced from this stage is a draft learning tool.

3. Development Stage

Stage***Develope***(development).throughseveral activities such as the expert validation test stage by expert validators which aims to determine the validity of the book. The authors can describe the results of several of the activities above as follows:

This textbook's validity testing activity will be carried out by three expert validators. The authors can describe the results of quantitative data and qualitative data from expert validators in Tables 1 and 2

Table 1. Quantitative Data Validity Test of Learning Tools

No.	Validator Name	Total Score	Question Items	Average	Percentage	Criteria
1	Validator 1	138	31	4.31	86.2%	Very Valid
2	Validator 2	131	31	4.09	81.8%	Very Valid
3	Validator 3	138	31	4.31	86.2%	Very Valid
Average				4.2	84%	Very valid

Table 2. Qualitative Data Validity Test of Learning Tools

No.	Validator Name	Comments and Suggestions
1.	Validator 1	a. The contents of the device are good, the accuracy of the contents is also good. b. There is some writing that is not clear, it should be corrected before use. c. The lesson plan is very good and describes a very good project.
2.	Validator 2	a. The device content is complete and very interesting, good for strengthening students' cognitive abilities. b. The front cover of the device is still not attractive, there are still empty parts.
3	Validator 3	The device is excellent, and is suitable for strengthening students' social skills and learning outcomes

Based on Table 1, information can be obtained that the project-based learning tools that have been arranged are in the very valid category. Furthermore, based on Table 2, information was obtained that the validator expressed comments that the contents of the device were very good, the appearance was attractive and was suitable for improving social skills and student learning outcomes. This means that the learning tools are valid for use in project-based learning to improve students' social skills and cognitive abilities

The next activity in the depelove activity is development testing. This activity is carried out by testing learning devices in class. Test activities were carried out in class X RPL semester II of SMKN 2 Mataram. This trial activity was carried out by implementing

learning using project-based mathematics learning tools (PjBl). Based on this activity, three data were obtained. This data can be described as follows

a. Data from observations of students' social skills

Observations on students' social skills were carried out by 2 observers. The observation process was carried out on 36 students. The results of observations by observers are presented in the following table.

Table 3. Data from Observation of Students' Social Skills

No.	Validator Name	Percentage	Criteria/Categories
1	Observer 1	90.3%	Very good
2	Observer 2	88.1%	Very good
	Average	89.2%	Very good

Based on Table 3 above, information is obtained that the average percentage of students' social skills scores reached 89.2% in the very good category. Thus it can be concluded that project-based learning tools are effectively used to improve students' social skills

b. Mathematical cognitive ability data Learning Toolkit

Data on students' cognitive abilities was obtained by providing cognitive ability evaluation test questions. The results showed that 82% of students achieved a complete score. The score obtained is greater than the Minimum Completeness Criteria (KKM) set by the school, namely 70. This means that project-based learning tools are effectively used to improve students' cognitive learning outcomes.

c. Teacher and student response questionnaire data

Teacher response data was obtained by distributing teacher and student response questionnaires. The distribution of this questionnaire was carried out at the last meeting for testing learning tools. This questionnaire was given to 36 students after learning using learning tools and 1 subject teacher after teaching using project-based learning tools. From the results of data analysis, the average score for teacher and student responses reached 4.2, reaching 93.3%, which is in the very good category. Thus it can be concluded that project-based learning tools are efficiently used to improve students' social skills.

The teacher further explained that this project-based learning tool is very easy to implement, the projects presented are problems that are close to the students' environment and culture, which really challenges students to think. This is in line with the findings of Rianti et al., (2020) that it is important to integrate cultural elements in learning tools to engage students and improve their learning outcomes.

4. Results of the Deseminate Stage

The Deseminate stage was carried out by providing 5 copies of project-based learning tools in the school library.

Based on the results of the research, it can be concluded that project-based learning tools are valid, efficient, and effective in improving social skills and student learning outcomes. Although the research finds that the development of learning tools is able to produce valid, practical and effective PBL learning tools to improve student social skill and learning outcome. However, in the implementation of this research there are limitations. One of them is that this research was done in one school with a limited number of samples. It may not be representative enough to generalize research findings to a wider population. Furthermore, this research does not fully control the external variables that may affect the outcome, such as the socio-economic background of students, the support of parents, and the learning environment at home.

In conclusion, the collective evidence from these studies supports the conclusion that project-based learning tools are indeed valid, efficient, and effective for enhancing social skills and improving student learning outcomes across various educational contexts. Project-based learning has been extensively studied in various educational settings, and the findings suggest that it is indeed a valid, efficient, and effective approach for enhancing social skills and improving student learning outcomes. Research by Insyasiska et al. Aska (2022) indicates that Project Based Learning can significantly impact student motivation, creativity, critical thinking skills, and cognitive abilities. Similarly, studies by (Rusnawati et al., 2021), (Baharullah et al., 2022), (Rahmawati et al., 2021), and Widodo et al. (2023) support the notion that project-based learning positively influences student learning outcomes and critical thinking skills across different subjects and educational levels.

Furthermore, the literature review by Kokotsaki et al. (2016) emphasizes that project-based learning is a student-centered instructional approach rooted in constructivist principles, promoting active student involvement, contextual learning, and social interaction to achieve learning goals. This aligns with the findings of (Guo & Yang, 2012), who highlight that project-based learning fosters comprehensive capacity development for both teachers and students through collaborative inquiry activities.

Moreover, the research by Musa et al. (2016) underscores how project work within project-based learning cultivates social learning by enhancing students' communication, negotiation, and collaborative skills. Additionally, studies by Anggaira (2022) and Ulya et al. (2020) reinforce the effectiveness of project-based learning in improving student learning outcomes and perceptions, further supported by the work of (Tegeh, 2023), which indicates that project-based learning can enhance student motivation and outcomes compared to traditional learning methods.

The findings of this research show that the role of project-based learning tools is very large in achieving mathematics learning objectives, especially statistics material. This finding is in line with the findings of several other researchers. Several studies highlight that project-based learning (PjBL) has an important role in enhancing effective

learning in various disciplines, including mathematics and biotechnology (Movahedzadeh et al., 2012; Hakim et al., 2019). PjBL has been proven to provide positive results in improving students' critical thinking skills, problem solving abilities and cognitive learning outcomes (Anggito et al., 2021).

The learning tools developed on a project basis refer to constructivism theory. This research shows that the constructivist approach plays an important role in the development of mathematics learning tools. Focusing on student-centered learning and active participation can have a positive impact on students' social interactions and communication skills (Zulaika & Syarifuddin, 2018).

CONCLUSIONS AND SUGGESTIONS

Based on the results of this research, it can be concluded that project-based learning tools are valid, efficient and effective for improving social skills and student learning outcomes.

For further research, it was suggested that we can continue to develop learning tools with a project-based learning model on other mathematical materials. Furthermore, research needs to be carried out with larger samples and from different schools or regions to improve the generalization of research findings.

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