

# Development of STEM Integrated Project-Based Learning Tools on Temperature and Heat Material to Improve Students' Generic Science Skills and Creativity: Feasibility Test

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**Abstract:** The aim of this research is to develop appropriate (valid and reliable) learning tools to improve students' generic science skills (KGS) and creativity. The tool developed was based on an integrated STEM project on temperature and heat material in terms of the validity and reliability of the instrument. These tools are in the form of syllabus, RPP, LKPD, and teaching materials as well as KGS instruments and creativity instruments. The type of research is Research and Development (R&D). Device development uses the ADDIE model (analysis, design, development, implementation, and evaluation). The research subjects were class XI MIA students at SMAIT Putri Abu Hurairah Mataram. The results of the syllabus validation obtained an Aiken V index score of 0.88 in the very valid category, RPP 0.84 in the very valid category, LKPD 0.81 in the very valid category, teaching materials 0.81 in the very valid category, KGS instruments 0.79 in the valid category, and creativity instrument 0.80 valid category. The overall average validation score is 0.82 with a very valid category. The results of the reliability of the syllabus, RPP, LKPD, teaching materials, KGS instruments and creativity are reliable with an average score of 93%. Based on these results, integrated STEM project-based learning tools are very feasible (valid and reliable) to be used in learning activities to improve students' generic science skills and creativity.

**Keywords:** Creativity; KGS; PjBL-STEM; Reliability; Validity

## Introduction

Education as an institution for the formation of human resources, has the main task of transmitting knowledge, forming human character and personality as well as future generations (Arifah et al., 2021). In its development, education is faced with the challenges of changing times and the character of the generation living today, namely generation Z (Hernandez-de-Menendez et al., 2020). Therefore, education in Indonesia is expected to be able to transform itself into changes in the technological era (Keshav et al., 2022). However, Indonesia is still far behind other Southeast Asian countries such as Singapore, Malaysia and Thailand (Fenanlampir et al., 2019). Based on Trends results in

International Mathematics and Science Study (TIMSS) in 2015, Indonesia was ranked 44th out of 49 countries (I. N. Dewi et al., 2020; Khodaria et al., 2019; Roshayanti et al., 2023; A. A. Setiawan et al., 2022). This condition means that Indonesian students are still struggling to be at a better level.

Among the things that are being done so that Indonesia's level develops is improving students' generic science skills and creativity (Pujani et al., 2022; Supena et al., 2021; Zulyusri et al., 2023). However, conditions at one of the schools, namely SMAIT Putri Abu Hurairah Mataram, have not yet optimized the development of these two skills. Researchers identified several problems, including: (1) The use of learning tools such as syllabus and lesson plans on temperature and

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heat material still follows the old format, lack of variety in teaching materials, rare use of media and LKPD, even though the 2013 curriculum requires the use of various sources, media and materials diverse teaching to support the learning process; (2) The lecture method is dominant compared to other methods such as projects or inquiry; (3) The level of achievement of student learning outcomes is still low; (4) The laboratory has not been utilized optimally as a place for experiments for students; (5) The use of technology in learning is limited because school regulations prohibit the use of smartphones, but the use of laptops is permitted during the learning process. Thus, it is necessary to develop learning tools that can facilitate students' generic science skills and creativity.

Generic science skills are important to master so that students have good mastery of science concepts, scientific attitudes and science process skills (Ni Putu et al., 2023). The development of learning tools has been carried out by several experts to improve generic science skills (Doyan, Susilawati, et al., 2022; Mulya et al., 2022; Nurdini et al., 2021; Nurjannah et al., 2021). The development of STEM (Science, Technology, Engineering, and Mathematics) based worksheets to improve generic science skills obtained a percentage of 87.80% in the very good category in the feasibility test (D. Setiawan et al., 2023).

Apart from generic science skills, in the learning process students also need to have creative thinking which must be developed, because through creative thinking, students are able to develop and find ideas related to views and concepts and emphasize aspects of rational thinking (Wahyuni et al., 2021). The development of learning tools has been carried out by several experts to increase students' creativity (Doyan et al., 2020; Najwa et al., 2022; Supiadi et al., 2023).

To support students' generic science skills and creativity, integrated STEM project-based learning tools on temperature and heat need to be developed. Because students are involved in solving real problems, working in groups, developing creativity, and developing solutions to real problems, projects can foster students' interest in science learning (Amri et al., 2020; Sumarni et al., 2019). Temperature and heat are materials that involve quite a lot of mathematical processes, so through project-based learning it is hoped that students will learn more conceptually than mathematically.

Through well-designed project-based learning, students can develop their creativity by investigating questions, finding solutions, and producing products based on the concepts learned (V. H. L. Saputri et al., 2020). According to Natty et al. (2019) this project-based learning model or PjBL can stimulate creativity. Apart from that, innovation skills can provide contextual

experiences to students (Mustika et al., 2020; Wicaksana et al., 2022; Yusika et al., 2021)

Project Based Learning learning model can be coordinated through a methodology that covers four aspects of abilities that students must master, namely STEM (Science, Technology, Engineering, and Mathematics). These four components are needed simultaneously to complete a project, so this strategy is able to create a cohesive and active learning system (Mawarni et al., 2020). The STEM approach has the potential to improve students' abilities in both generic science skills and creative thinking (D. Setiawan et al., 2022; Widiastuti et al., 2019). The skills to think and act based on scientific knowledge are known as generic science skills.

Based on the description above, a feasibility test was carried out on an integrated STEM project-based learning tool on temperature and heat material to improve students' generic science skills and creativity.

### Method

Research and Development is a type of research used by researchers with the ADDIE development model which includes five stages, namely analysis, design, development, implementation and evaluation (Doyan, Khairunnisa, et al., 2022). However, this research only reached three stages, namely analysis, design and development.

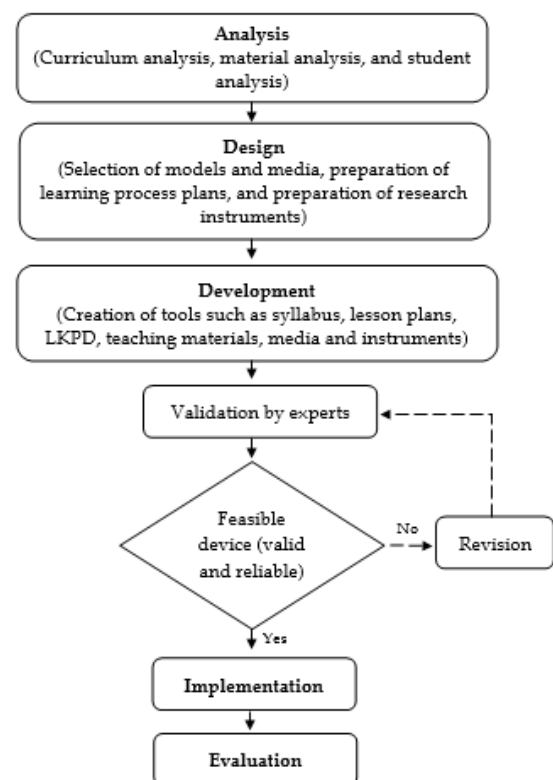


Figure 1. Research flow

At the analysis stage Curriculum analysis, material analysis, and student characteristics analysis were carried out. Analysis was carried out through interviews with physics teachers covering curriculum, learning tools, student characteristics, learning processes, and evaluation. At the design stage, models and media are selected, learning process plans are prepared, and research instruments are prepared. The researcher chose the PjBL model with the media in the form of a simple calorimeter, designed tools in the form of a syllabus, RPP, LKPD, teaching materials, and compiled a grid of research instruments. At the development stage, tools such as syllabi, lesson plans, LKPD, teaching materials, media and evaluation instruments are made. Next, a device validation test was carried out by three validators. The learning device validity instrument is in the form of a validation questionnaire given to the validator. The research flow can be seen in Figure 1.

Aiken's V formula is a data analysis technique for measuring the level of validity of integrated STEM project-based learning tools as follows.

$$V = \frac{\sum S}{n(c-1)} \tag{1}$$

Information:

V : Rater agreement index

S: r - lo

lo : lowest score

c : the number of categories that the rater can choose

r : score set by the rater

n: number of raters

Then the data is interpreted based on validity criteria. The level of validity is determined based on Table 1.

**Table 1.** Validity Level (Aiken, 1997)

Value range	Validation Level
$\leq 0.4$	Not valid
$0.4 < V < 0.8$	Valid
$V \geq 0.8$	Very valid

Furthermore The reliability of device validation results is based on the level of reliability by expert validators using the Borich method, known as *Percentage of Agreement (PA)*, namely the percentage of value agreement between the first, second and third validators.

$$PA = \left(1 - \frac{A-B}{A+B}\right) \times 100\% \tag{2}$$

Information:

PA :Percentage of Agreement

A : Highest score

B : Lowest score

The average value of *Percentage of Agreement* is determined by combining the validation results from the

three validators. Combination of first and second validator (V12), second and third validator (V23), and third and first validator (V31). If the Percentage of Agreement value obtained is  $\geq 0.75$  or  $\geq 75\%$ , then the learning device validation results can be said to be reliable (Makhrus et al., 2020).

## Results and Discussion

An integrated STEM project-based learning tool has been developed to improve students' generic science skills and creativity using the ADDIE model including analysis, design and develop.

### Analysis Results

The curriculum used at SMAIT Putri Abu Hurairah Mataram is the 2013 revised 2019 curriculum. The 2013 curriculum is a curriculum oriented towards developing the competence and character of students. This curriculum aims to equip students with various relevant skills and attitudes, so that they can keep up with current developments well (D. R. Dewi, 2019; Gumelar et al., 2022; Ramdhani, 2018). The important thing to pay attention to is the learning tools used by educators to improve students' competencies. Learning tools are tools that must be prepared by educators in the learning process to achieve a goal so that learning becomes more focused and effective (Najwa et al., 2022; Tanjung et al., 2022). Meanwhile, teachers must be able to create science learning tools to help students learn 21st century skills (Harjono et al., 2019).

Based on observations, students are very enthusiastic about learning when it comes to concepts and practices (Diraya et al., 2021; Rizaldi et al., 2020). This is because students prefer material that is conceptual rather than mathematical (Mulyani, 2019). So that learning tools such as syllabi, lesson plans, worksheet, teaching materials, media and evaluation instruments are designed in such a way as to produce a product. Creating a product through a scientific process is a thinking ability at the highest level (Ramadhani et al., 2021).

### Design results

Project-based learning on temperature and heat material is combined with media designed by researchers in the form of a simple digital calorimeter as in Figure 2. This digital calorimeter is used in demonstration activities during learning to measure the temperature and heat of an object. In this case the researcher chose the STEM integrated PjBL model. This model focuses on projects and teaches curriculum concepts so that students can collaborate, work

independently, and prepare themselves for real life (Nurhadiyati et al., 2021; Octaviyani et al., 2020).



Figure 2. Digital calorimeter

Design initial research instruments such as feasibility, practicality and effectiveness instruments. The aim is to produce physics learning tools that are valid, reliable, practical and effective (Hidayatin et al., 2022; Sholihah, 2022; Wati et al., 2022). The design of the feasibility instrument is designed based on the criteria that must be met in developing a device. These criteria include format, content, grammar, indicators, objectives, breadth of material, and assessment. The instrument was given to expert validators to assess whether or not the tools developed by researchers were suitable for implementation with students.

**Development Results**

Based on the design results, the researchers then developed an integrated STEM project-based learning tool (Budhi et al., 2021; Rochim et al., 2021). These tools are syllabus, RPP, LKPD, teaching materials, generic science skills instruments, and creativity instruments. The tools that have been prepared are validated by three expert validators, then revised based on suggestions from the validators (S. W. Saputri et al., 2022; Sumiati et al., 2022). The validation results of integrated STEM project-based learning tools can be seen in Table 2 and Table 3.

**Table 2.** Validation Results of STEM Integrated Project Based Learning Tools

Device	V	Category
Syllabus	0.88	Very Valid
lesson plan	0.84	Very Valid
LKPD	0.81	Very Valid
Teaching materials	0.81	Very Valid
KGS test	0.79	Valid
Creativity test	0.80	Valid
Average	0.82	Very Valid

**Table 3.** Reliability Test Results for Integrated STEM Project-Based Learning Tools

Device	PA (%)	Category
Syllabus	94.81	Reliable
lesson plan	95.25	Reliable
LKPD	94.31	Reliable
Teaching materials	92.07	Reliable
KGS test	90.77	Reliable
Creativity test	90.76	Reliable
Average	93.00	Reliable

Based on the table above, the average validation and reliability score for learning tools is 0.82 with a very valid category and 93% reliable category with slight revisions (Januarti et al., 2023; Wasli et al., 2022; Widiawati et al., 2022). This means that this device is worthy of being implemented to improve KGS and student creativity. This is in accordance with research by Ridha et al. (2022) that the learning tools with the STEM-based PjBL model developed are very suitable for use to increase students' creativity.

This research is also relevant to Pratiwi's (2021) research that students' creativity can be increased using science learning tools using the Project Based Learning (PjBL) model with a STEM approach. Research by Setiawan et al. (2022) also states that students' generic science skills can also be improved through the development of STEM-laden LKPD.

**Conclusion**

Based on the results and discussion, it can be concluded that the integrated STEM project-based learning tool on temperature and heat material is feasible (valid and reliable) for increasing students' creativity and generic science skills.

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Author 1 (Researcher), Author 2 (Supervisor I), Author 3 (Supervisor II).

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