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Development of Problem Based Learning Model Tools with Google Classroom to Improve Students' Mastery of Temperature and Heat Concepts

Eka Nur Wulandari Abdullah[1*], Sutrio[1], Syahrial Ayub[1], Aris Doyan[1]

[1] Department of Physics Education, Faculty of Teacher Training and Education, Universitas Mataram, Indonesia.

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Corresponding Author:
Eka Nur Wulandari Abdullah
ekanurwulandaria09@gmail.com

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Abstract: This research aims to produce Problem Based Learning model learning tools using Google Classroom that are feasible, effective and practical to improve students' mastery of concepts in temperature and heat material. This type of research is development research (Reasearch and Development) using a 4D model (Define, Design, Development and Disseminate). The products that have been developed in this research are syllabus, RPP, LKPD, Google Classroom, and concept mastery test instruments. Data on the feasibility, effectiveness and practicality of learning tools were obtained from feasibility tests, N-gain tests and practicality tests. Feasibility data was obtained from the assessment of 6 validators consisting of 3 expert validators from Physics Education Lecturers at Mataram University and 3 practitioner validators from Physics Teachers at SMAN 3 Mataram. Effectiveness data was obtained from the results of the N-Gain test conducted on 17 students at SMAN 3 Mataram. Practicality data was obtained from observations of learning implementation and student response questionnaires. The results of the device feasibility test analysis were obtained at 89.70% with very feasible criteria. The results of the effectiveness test analysis using the N-gain test results were obtained at 73%, which is in the high category and the criteria are quite effective. The practicality test results were obtained at 90% with very practical criteria. Based on the results of the data analysis that has been obtained, it can be concluded that the learning tools that have been developed using the Problem Based Learning model with Google Classroom are declared feasible, effective and practical for increasing students' mastery of concepts in temperature and heat material.

Keywords: Concept mastery; Google classroom; Problem based learning; Temperature and heat

Introduction

Currently, Indonesia has entered the super smart society 5.0 era, which is characterized by the increasingly central role of technology in human life (Gladden, 2019; Marjuni et al., 2022). The concept of Society 5.0 was adopted by the Japanese government in anticipation of global trends as a result of the emergence of the industrial revolution 4.0 (Putra, 2019; Tavares et al., 2022). Education in the Era of Society 5.0 plays a role in advancing the quality of human resources where everyone is required to be more creative, innovative, productive, and able to adapt well and collaborate. There has not been much implementation that can be seen in the field, especially in physics lessons, this can be seen from students not having explored and interacted

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much with information technology and the lack of collaboration in information technology (Nurazizah et al., 2021).

Physics is a part of science that focuses on the study of matter, energy and the relationship between the two. Learning Physics is generally considered difficult by students. This is due to the large number of abstract physics concepts and the large number of formulas, making it difficult for students to understand the concepts of physics learning. In accordance with the results of observations made by SMAN 3 Mataram, it shows that physics subjects are rated as difficult by students. One material that is difficult to understand is temperature and heat. Based on the results of research conducted by Azizah et al. (2015) and Tanti et al. (2020), students' difficulties in learning physics are found in certain materials, one of which is temperature and heat because the concepts of temperature and heat are too abstract, giving rise to various different thoughts in students, which as a result Many people have an understanding that is not in accordance with what is actually meant. Based on this, it can be seen that students' mastery of concepts is still low, and an appropriate learning model is needed to improve students' mastery of physics concepts (Sulman et al., 2023).

One learning model that can improve students' mastery of concepts is the Problem Based Learning (PBL) learning model (Gallagher et al., 1992; Yulianti et al., 2019). Problem Based Learning (PBL) is an innovative learning model that is student centered. This model actively involves students to solve a problem, so that it can increase students' interest in learning. The PBL model can also increase students' mastery of concepts. This is in accordance with the results of research from Yan et al. (2024) and Yusuf et al. (2022), stated that the PBL model can have a fairly high effect on students' mastery of concepts and critical thinking in physics subjects. One of the media that can support learning and is in accordance with education in the era of society 5.0 which is based on the use of technology (Widiasanti et al., 2023). Nowadays, technology plays a very important role in education (Purbasari, 2023; Ratnasari et al., 2019). Based on this, assistance in the form of media is needed, one of the media that can be utilized and is in accordance with education in the era of society 5.0 and the Problem Based Learning (PBL) model is Google classroom (Erlangga et al., 2021; Gusmaweti et al., 2023). Google classroom is a platform that can be used as a medium to help the learning process. Google classroom is a suitable medium when combined with the Problem Based Learning learning model (Atikah et al., 2021; Yusuf et al., 2022). Based on research conducted by Widyaningsih et al. (2019), and Wijayanto et al. (2023), the influence of the PBL model using Google Classroom media can have quite a high influence on students' HOTS skills. Based on the description of the problem, this is the reason for researchers to innovate learning by developing PBL model learning tools with Google Classroom to improve students' ability to master the concepts of temperature and heat.

Method

This research uses a type of development research or research and development (Mufadhol et al., 2017). Ddevelopment research is research used to produce certain products and test the effectiveness of these products. The product that will be produced in this research is a Problem Based Learning tool with Google Classroom to improve students' mastery of the concepts of temperature and heat. This research consists of 4 stages: Define, Design, Develop (development), and Disseminate. The subjects of this research were students in class XI MIPA 1 for the 2023/2024 academic year at SMAN 3 Mataram. This research was carried out in July 2023, with data collection time at schools from July 1 to July 24 2023.

The research instruments used in this research were observation and interview guide sheets, learning device feasibility test sheets, test sheets, and response questionnaires. The data collection technique was carried out using a feasibility test of learning devices assessed by 6 validators consisting of 3 expert validators namely Physics Education Lecturers, FKIP at Mataram University and 3 practitioner validators namely Physics Subject Teachers at SMAN 3 Mataram. Assessment is carried out through a feasibility sheet with a scale of 1 - 4 where 1 means not good, 2 means not good, 3 means good, and 4 means very good. Then the effectiveness data was obtained from the pretest and posttest test sheets, the results of which were calculated using the N-gain test and practicality data was obtained from the responses of teachers and students. The data analysis technique for testing the feasibility of learning devices is carried out using a Likert scale where a score is given to each statement or aspect assessed and added up after which the percentage value is calculated using equation 1.

$$P = \frac{f}{N} \times 100\% \quad (1)$$

Information:
P = Percentage number
F = Score obtained
N = Maximum number of scores

The percentage data obtained is then converted into eligibility criteria for learning tools listed in table 1

Table 1. Eligibility Criteria for Learning Tools

Percentage (%)	Eligibility Criteria
$80 < score \leq 100$	Very worthy
$61 < score \leq 80$	Worthy
$41 < score \leq 60$	Decent Enough
$21 < score \leq 40$	Not Worth It
$0 < score \leq 20$	Not feasible

Next, to find out the results of improvements in students' mastery of concepts, from temperature and heat material, a pretest and posttest were carried out. The results of the pretest and posttest are then calculated using the N-gain test with the following equation 2.

$$\text{N} - \text{Gain} = \frac{\overline{\text{X}}_{\text{Post}} - \overline{\text{X}}_{\text{Pre}}}{\overline{\text{X}}_{\text{Max}} - \overline{\text{X}}_{\text{Pre}}} \quad (2)$$

Information:
$\overline{\text{X}}_{\text{Post}}$ = post-test score
$\overline{\text{X}}_{\text{Pre}}$ = pre-test score
$\overline{\text{X}}_{\text{Max}}$ = maximum score

Based on the data obtained, it is then converted into categories and criteria for the effectiveness of learning tools based on table 2 and table 3.

Table 2. Interpretation of the N-gain Index

N-Gain Score (g)	Category
0.70 < g < 1.00	Tall
0.30 < g < 0.70	Currently
0.0 < g < 0.30	Low

Table 3. N-Gain Acquisition Criteria

Percentage N-Gain (%)	Criteria
>76%	Effective
56% − 75%	Effective enough
40% − 55%	Less effective
<40%	Ineffective

To find out the practicality of learning tools, this is done by providing an observation sheet on the implementation of learning by the teacher and a student response questionnaire. This practicality analysis was carried out using a Likert scale where a score was given to each statement or aspect assessed and added up after which the percentage value was calculated using the equation.

$$P = \frac{f}{N} \times 100\% \quad (3)$$

Information :
P = Percentage number
F = Score obtained
N = Maximum number of scores

The percentage data obtained is then converted into eligibility criteria for learning tools listed in table 4.

Table 4. Practicality Criteria for Learning Tools

Percentage (%)	Practicality Criteria
$80\% < score \leq 100\%$	Very Practical
$61\% < score \leq 80\%$	Practical
$41\% < score \leq 60\%$	Quite Practical
$21\% < score \leq 40\%$	Less Practical
$0\% < score \leq 20\%$	Impractical

Result and Discussion

Research Result

In this research, we have developed a Problem Based Learning model using Google Classroom to improve students' mastery of the concepts of temperature and heat. The following are the results of the research carried out in class XI MIPA 1 SMAN 3 Mataram. The learning tools that have been developed are; syllabus, RPP, LKPD, Google Classroom, and test instruments. The learning tools are then tested for feasibility, effectiveness and practicality. In the feasibility test analysis, the learning tools were tested by 6 validators consisting of 3 expert validators, namely Physics Education Lecturers, Mataram University and 3 practical validators, namely Physics subject teachers at SMAN 3 Mataram. A learning device can be said to be feasible if the feasibility test assessment falls within the appropriate criteria. The analysis results from the feasibility test of learning devices by validators are as follows.

Table 5. Test the Learning Device Feasibility Analysis Results by Validators

Learning Media	Average	Criterion
Syllabus	90.40	Very Worth It
Lesson plan	89.50	Very Worth It
LKPD	88.80	Very Worth It
Google Classroom	88.40	Very Worth It
Test instrument	91.40	Very Worth It
Average Percentage of Learning Sets	89.70	Very Worth It
Criteria		

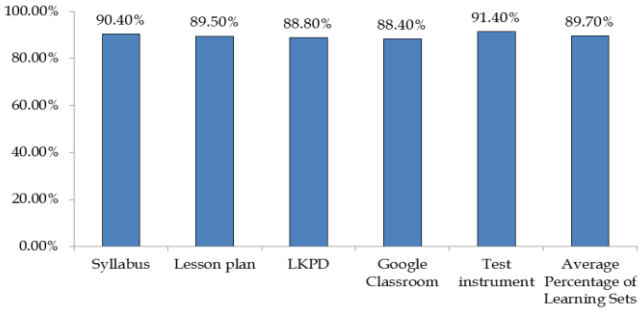

Figure 1. Results of learning device feasibility test analysis by validators

Based on table 5 and figure 1, it can be seen that the learning tools are included in the very appropriate criteria with a percentage of 89.70% so that the learning tools that have been developed are suitable for use in learning activities. Next, the effectiveness test analysis was analyzed using the N-gain test, which was obtained from the pretest and posttest scores to determine the increase in students' mastery of concepts in temperature and heat material. The pretest and posttest were tested on 17 students in class XI MIPA 1 SMAN 3 Mataram. The analysis results from the device effectiveness test from the N-gain concept mastery test results are as follows.

Table 6. N-Gain Test Results for Students' Concept Mastery Ability

$\bar{X}_{Pre}$	$\bar{X}_{Post}$	$\bar{X}_{Post} - \bar{X}_{Pre}$	$\bar{X}_{Max} - \bar{X}_{Pre}$	N-Gain	N-Gain	Category	Criteria
13.7	75	61.30	86.30	0.73	73%	Tall	Effective enough

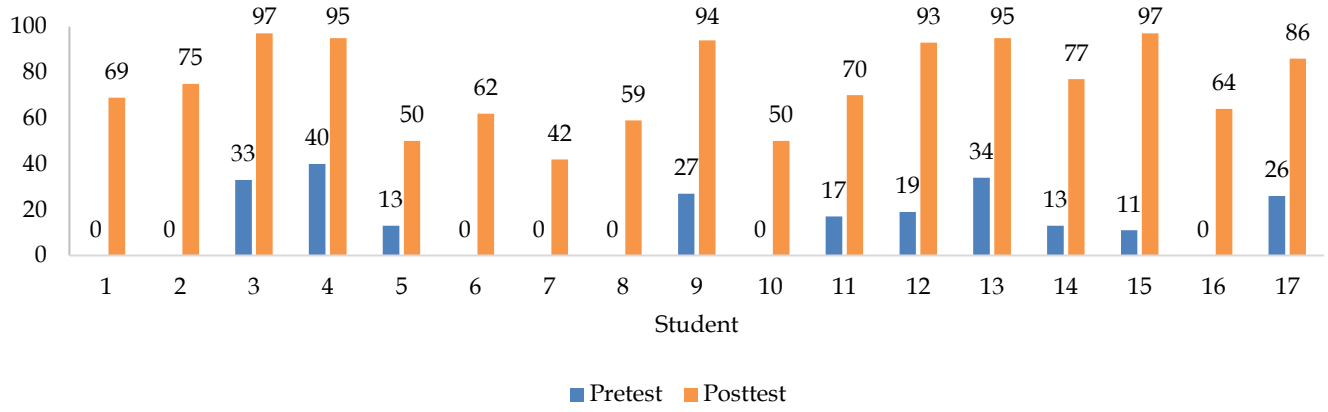

Figure 2. Diagram of student pretest and post-test results

Based on table 6 and figure 2, it can be seen that the effectiveness of the learning tools is in the high category which is included in the criteria of being quite effective. So, it can be concluded that there has been an increase in students' mastery of concepts. Next, there is an analysis of the practicality of the learning tools from the results of observations of implementation by the teacher and questionnaires on student responses to the learning that has been carried out. The analysis results from the practicality test of learning devices are as follows.

Table 7. Practicality Test Analysis Calculation Results

Assessment Aspects	Practical Value	Criteria
Learning Implementation Observation Sheet	95	Very Practical
Student Response Questionnaire Based on assessment per student	95	Very Practical
Student Response Questionnaire Based on assessment aspects	79	Practical
Average Percentage	90	
Average Criteria		Very Practical

Based on table 7, it can be seen that the learning tools are very practical to use in implementing the learning process, apart from that. Based on these results, it indicates that there is a positive response from students to the learning activities that have been implemented.

Discussion

Learning Device Eligibility

The learning tools were prepared in 3 meetings. The learning tools that have been developed are analyzed to obtain data on the feasibility of the learning tools. This data was obtained from the results of a feasibility test carried out by 6 validators consisting of 3 expert validators and 3 practitioner validators. The feasibility test of learning tools is determined from a 1-4 Likert scale assessment, where 1 means strongly disagree, 2 means disagree, 3 means agree and 4 means strongly agree. So that the results of the feasibility test of learning devices were obtained with an average percentage of 89.7%, therefore the learning devices that have been developed by researchers are included in the Very Feasible criteria, and can be used in learning. This is in line with Makhrus et al. (2020), who said Learning tools that are categorized as valid and reliable can be used as a guide for teachers when carrying out learning activities in class.

Syllabus Eligibility

The syllabus is one of the most important components of learning tools, which is used as a reference in preparing other learning tools (Murphy et al., 2023). The syllabus that has been developed is the result of modifications to the revised 2013 syllabus using a problem based learning model and using Google Classroom media, which is used for the learning process in class. The syllabus that has been developed by researchers contains several components, namely syllabus identity, core competencies (KI), basic competencies (KD), main material, learning activities, learning indicators, time allocation, type and form of assessment and media. This is in accordance with research carried out by (Kazemi et al., 2020). The contents of the syllabus components are assessed by validators so that they can find out whether the syllabus is suitable or not for use in the learning process.

Based on analysis of the syllabus feasibility test, the average percentage value of the syllabus that has been assessed by expert validators and practitioner validators is 90.40%. This shows that the syllabus that has been developed falls within the criteria of being very feasible and can be used or applied in learning at school. This is in accordance with research conducted by Parker et al. (Parker et al., 2022), that the syllabus that has been developed with a percentage of 86.9% falls into the category worthy. However, there is still something that needs to be improved based on suggestions and comments provided by expert validators and practitioners. Based on this, overall the syllabus developed in this research is suitable for use in the learning process in schools. Because it contains all syllabus components in accordance with applicable school regulations. Where the syllabus components created generally contain competency standards, basic competencies, indicators, main material, learning activities, assessments, time allocation and learning resources (Falloon, 2020), all of these components have been included in the syllabus created by the researcher.

Feasibility of Learning Tool Plans (RPP)

The learning implementation plan (RPP) is short-term planning to estimate the things that will be done in learning activities. The RPP developed by the researcher is prepared based on a syllabus reference that has been developed and compiled to direct the researcher in designing the learning activities that will be carried out. This lesson plan is designed to make it easier for researchers to carry out learning in schools. The RPP that has been designed by researchers has several components, namely the identity of the RPP, core competencies (KI), basic competencies (KD), competency achievement indicators (GPA), learning objectives, learning materials, learning strategies, media (tools and materials), learning resources. The learning steps and assessment instruments of these components are assessed by validators so that they can find out whether the syllabus is suitable or not to be used in the learning process.

Based on the analysis of the RPP feasibility test, the results of the average percentage analysis of the RPP feasibility test from expert validators and practitioner validators were 89.5%. This shows that the RPP that has been developed falls within the criteria of being very feasible and can be used or applied in learning at school. However, there is still something that needs to be improved based on suggestions and comments provided by expert validators and practitioners. This is in accordance with research conducted by Bai et al. (2018), that if the feasibility percentage is above 88.02% it is in the very feasible category. Based on this, overall the RPP uses the problem based learning model with Google Classroom which was developed and is suitable for use in the learning process in schools.

This is because the RPP that has been developed contains all RPP components that are in accordance with applicable government regulations. Where according to the Minister of Education and Culture Regulation No.22 of 2016, the learning RPP contains the RPP identity (school identity, subject identity or theme/sub-theme, class/semester, main material, time allocation) core competencies (KI), basic competencies (KD), indicators Competency achievement (GPA), learning objectives, learning materials, learning methods, learning media, learning resources, learning steps, assessment instruments, all of these components are in the RPP which has been prepared by the researcher. This is in accordance with research conducted by Nasrah et al. (2021).

Feasibility of Student Worksheets (LKPD)

Student worksheets (LKPD) are sheets containing discussion activities or experimental trials carried out by students. LKPD in this development research is used as an auxiliary media to assist students in solving problems. The LKPD that has been developed by the researcher consists of several components, namely cover, title, names of group students, instructions for working on the LKPD, objective of the experiment, problem formulation, tools experimental procedures, results of observations and questions and finally the conclusion. .

The LKPD in this study used 3 simple experimental activities that are commonly encountered in everyday life. Where the LKPD that has been developed is assessed by a validator so that it can be seen whether the LKPD is suitable or not for use in the learning process. Based on the analysis of the LKPD feasibility test, the average percentage of LKPD feasibility tests from expert validators and practitioner validators is 88.8%. This

shows that the LKPD that has been developed falls within the criteria of being very feasible and can be used or applied in learning at school. This is in line with research by Ahmadiyanti et al. (2021), which shows that a percentage of 85% is in the very feasible category. However, there is still something that needs to be improved based on suggestions and comments provided by expert validators and practitioners. Based on this, LKPD is suitable for application in learning. This is also because the LKPD prepared by the researcher contains interesting pictures and gives rise to experimental activities that can support students' knowledge to improve students' ability to master concepts. Apart from that, the LKPD also uses sentences that are easy to understand, making it easier for students to work on the LKPD.

Google Classroom Eligibility

Google Classroom is an alternative media that can support learning activities to meet educational demands in the era of society 5.0. This Google Classroom is structured based on the steps in the learning activities in the RPP. Google Classroom is a learning media that is suitable for use when combined with a problem based learning model and meets the demands of the era of society 5.0, which is carried out online and without being limited by space and time. Google Classroom is assessed by validators so that we can find out whether Google Classroom is suitable or not to be used in the learning process.

Based on analysis of the Google Classroom feasibility test, the average percentage of Google Classroom feasibility tests from expert validators and practitioner validators is 88.40%. This shows that the Google Classroom used falls within the criteria of being very feasible and can be used or applied in learning at school. This is in accordance with research by Adelina and Triwahyuningtyas et al. (2020), the results of the Google Classroom feasibility percentage based on the expert assessment results were 88.55%, falling into the feasible category. However, there is still something that needs to be improved based on suggestions and comments provided by expert validators and practitioners. Based on the results of the assessment and data analysis as well as suggestions and comments provided by validators, Google Classroom is suitable for implementation in school learning. This is also because Google Classroom contains clear components, and all existing features can be accessed easily and are able to help learning activities. This is in line with the results of other research conducted by Hayati et al. (2021), online learning using the PBL model and assisted by Google Classroom can increase mastery of concepts.

Feasibility of Concept Mastery Test Instruments

The test instrument is one part of the learning tool that is used to measure the achievement of competency in learning. The test instrument compiled by the researcher is intended to measure students' ability to master concepts. This test instrument is made in the form of an essay test and consists of 10 questions that refer to indicators of concept mastery. The test instrument was given to students twice, namely before learning (pretest) to measure students' initial knowledge and after learning activities (posttest) to measure whether there was an increase in students' mastery of concepts. Based on analysis of the test instrument feasibility test, the average percentage of test instruments that have been assessed by expert validators and practitioner validators is 91.4%. This shows that the concept mastery test instrument that has been developed falls within the criteria of being very feasible and can be used or applied in learning. However, there is still something that needs to be improved based on suggestions and comments provided by expert validators and practitioners.

Based on this, overall the test instrument developed in this research is suitable for use in the learning process in schools. Based on the overall assessment, suggestions and comments, the test instrument learning tool to improve students' mastery of concepts is suitable for application in learning at school. This is because the test instrument created contains indicators in accordance with the indicators of concept mastery.

Effectiveness of Learning Tools

The effectiveness of the problem based learning model learning tools developed by researchers can be seen from the increase in the results of students' concept mastery abilities. Initial learning was carried out by asking students to do a pretest, then the researcher taught the students 3 meetings with temperature and heat material. In these 3 meetings, the researcher applied other learning tools, namely, LKPD according to the material discussed at each meeting. After all the material delivery has been completed, in the final stage a posttest is carried out to test the increase in students' concept mastery abilities. This effectiveness test was carried out on students at SMAN 3 Mataram in class The results of the pretest average score indicate that students' concept mastery abilities are classified as low. After the learning process was carried out by applying the problem based learning model, the posttest results were obtained with an average score of 75.

After the pretest and posttest scores are obtained, an analysis of the increase in students' concept mastery abilities is carried out using the N-Gain test. From this test, an average N-Gain value of 0.73 or a percentage of 73% was obtained, so based on this data it can be stated that the effectiveness of the learning tools that have been

developed is in the high category, which is included in the criteria of being quite effective. The effectiveness of e-learning with Google Classroom as a learning medium is in the quite effective category with a percentage of 77.57%. Apart from that, based on the results of (Ansari et al. (2020) it is stated that Google Classroom can play a role as a learning medium in the current era of digitalization with a percentage of 83%.

From the results of the N-gain calculation for the pretest and post-test, students have experienced an increase. Increasing the ability to master concepts varies with each student. This can occur due to differences in abilities in capturing learning material for each student. Based on this and according to the interpretation of the effectiveness of Haleem et al. (2022) and Gregory et al. (2017), the learning tools that have been developed fall within the criteria of being quite effective. Based on the category, and the average N-Gain results obtained show that the use of problem based learning tools has proven to be effective in increasing students' concept mastery abilities. The Google Classroom model and media as well as the learning tools used play an important role in the results of increasing students' ability to master concepts (Nguyen et al., 2022). Each learning tool has its own role.

The syllabus acts as a reference in developing lesson plans. The lesson plan acts as a guide in learning activities, so that the problem based learning model developed can be applied well to students. Google Classroom acts as a forum for learning and training students to use information technology. LKPD acts as a supporting teaching material, so that students play a more active role in the learning process and learn to carry out discussions and solve problems in everyday life. And the test instrument acts as a measuring tool to determine the increase in knowledge, ability to master concepts from students. So that the achievement of indicators in the learning objectives that have been set can be achieved.

This is in line with the results of other research conducted by Saputri (2021), online learning using the PBL model and assisted by Google Classroom can increase mastery of concepts. Therefore, learning tools with a problem based learning model can help students to play a more active role and can involve students' abilities in discovering concepts in a more structured way, so that students' ability to master concepts can increase (Darling-Hammond et al., 2020).

Practicality of Learning Tools

The practicality of learning tools is obtained from observations of learning implementation and response questionnaires given to teachers and students regarding learning carried out in class. Analysis of observations of learning implementation and questionnaire responses was obtained using a Likert scale. The aspects assessed are based on learning activities in the RPP which have been developed by researchers using a problem based learning model with Google Classroom with 3 meetings. In this study, the observation sheet on the implementation of the learning process was assessed by the observer, namely the class XI physics teacher at SMAN 3 Mataram. Meanwhile, the response questionnaire was given to 17 students in class XI MIPA 1 SMAN 3 Mataram. The results of the observation of implementation and response anchors were then calculated, so that an average score for learning implementation was obtained, which was 95% and was classified as very practical criteria. This shows that the stages in the problem-based learning model learning process with Google Classroom can be considered very practical.

Based on the response questionnaire that has been filled in by students, all students are in the very practical criteria with an average percentage of 95%. Apart from that, the student response questionnaire was also analyzed based on each assessment aspect and the average percentage obtained for all assessment aspects in the response questionnaire was 79% and fell within the practical criteria. This shows that the use of learning tools in learning activities by implementing a problem based learning model with Google Classroom gets a very positive response from students. This is in line with the results of Murdiyah et al. (2020), research on Google Classroom with a problem based learning model which has proven that students provide positive responses in learning activities. Apart from that, based on research results from Markula et al. (2022), the implementation of the PBL learning model with the help of Google Classroom received a positive response from students.

The results of the analysis of student response questionnaires show that all students responded positively to the trial of the learning tools they received. This indicates that students are interested in the atmosphere of the learning process and the application of syntax in the problem based learning model with Google Classroom which has been implemented in the learning process.

Conclusion

Based on the results of the research and discussion on the development of learning tools, the following conclusions were obtained. Problem Based Learning model learning tools with Google Classroom to improve students' mastery of concepts in temperature and heat material were proven to be feasible and were in the very feasible category, with the average percentage of the validators, the syllabus is 90.40%, RPP is 89.5%, LKPD is

88.80%, Google Classroom is 88.40% and test instruments are 91.4%, so the average percentage of the feasibility test for learning tools as a whole is 89.70%. Problem model learning tools Based Learning with Google Classroom can improve students' mastery of concepts in temperature and heat material, this was proven after researchers carried out an effectiveness test using the N-Gain test with an average percentage value of 73% in the High category and included in the Quite Effective criteria. The learning tool based on the Problem Based learning model with Google Classroom to improve students' ability to master concepts in temperature and heat material has proven to be practical and falls within the very practical criteria. This is evident from the results of the average score for the implementation of the learning process of 95%, the student response questionnaire based on the assessment of each student was 95% and the student response questionnaire based on aspects of the assessment was 79%, so that it is based on the results of the average test analyst score. overall practicality of 90%

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Author Contributions
E. N. W. A,: conceptualized and selected the methodology, prepared to write the original draft, carried out analysis according to the methodology, conducted research, and wrote down the results and discussed the research results. S., S., A, and A. D: as supervisors and research data validators.

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Conflicts of Interest
The authors declare no conflict of interest.

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