JURNAL BIOTERDIDIK: WAHANA EKSPRESI ILMIAH
(*Journal of Bioterdidik: Scientific Expression Media*)

Vol. 11 No. 3, December 2023, page. 334-347
http://jurnal.fkip.unila.ac.id/index.php/JBT/
doi: 10.23960/jbt.v11.i3.31060

e-ISSN: 2621-5594
p-ISSN: 2302-1276

Development of Problem-Based Science Practicum Instructions of Junior High School Students

Irwandi Rahmat[1]*, Skonchai Chanunan[2], Ahmad Yani[3]
[1]Science Education, Faculty of Matematic and Natural Sciences, Universitas Negeri Makassar, Andi Pangeran Pettarani Street, Makassar, Indonesia
[2]Science Education, Faculty of Education, Naresuan University, Phitsanulok, Thailand,
[3]Biology Education, Faculty of Mathematics and Natural Sciences, Universitas Terbuka, Jakarta, Indonesia
*C*orresponding author*: irwandi.rahmat@unm.ac.id

Received: November 8, 2023 *Accepted: December 20, 2023* *Online Published: December 30, 2023*

Abstract: This study aims to develop problem-based science practicum instructions intended for grade VIII junior high school / MTs students in the odd semester. The problem-based approach was chosen because it has been proven effective in improving students' critical thinking and problem-solving skills. This research uses the 4D method which includes the Define, Design, Develop and Disseminate stages. The results of this study indicate that the problem-based practicum instructions developed are valid, practical and effective. The validity value is 4.2 which means that the problem-based practicum instructions are included in the valid criteria. The practicality value is 4.6 which means that the problem-based practicum instructions are classified as practical criteria. The problem-based practicum instructions developed have also been classified as effective by looking at the results of positive responses from students which reached 84.8%. The final product resulting from this research is expected to be a reference for teachers in teaching science with a problem-based approach, to improve the quality of science learning in schools.

Keywords: practical guidelines, science learning, junior high students

INTRODUCTION

The first curriculum used in Indonesia was the 1968 curriculum. This curriculum aims to establish the foundation of citizenship and statehood by instilling the Pancasila ideology. In this curriculum, the largest portion is moral and civic education and religious education. Meanwhile, science education has not received an adequate place (Sulisyowati & Wisudawati, 2002).

A few years later, a revision was made to the 1975 curriculum which sought to develop cognitive, psychomotor and affective aspects. So that science education or Natural Sciences has become an important element, while English is only an additional lesson. A while later the 1985 Curriculum was formed

which increased the application of the Active Student Learning Method (CBSA) which wanted the teacher's role as a facilitator and did not dominate learning. Based on CBSA, science lessons should be conducted in the laboratory as a direct experience process and students are placed as the subject of learning (Agustina, 2018).

Science learning should be carried out in a *scientific inquiry* to foster the ability to think, work and scientific attitudes and communicate them as important aspects of life skills. Therefore, science learning in junior high school/MTs emphasizes on providing direct learning experience through the use and development of process skills and scientific attitudes (Agustina dkk, 2021). The development of process skills and scientific attitudes can support the abilities expected in the 21st century knowledge era including the ability to solve problems and student creativity, so that at this time various ways must be done so that young generations are able to have such abilities (Hidayat, 2021). One way that is usually done is to implement learning that makes students independent, for example in practicum activities at school.

The reality of the learning concept that occurs in science learning, which is more focused on products by utilizing concepts and theories. This situation is getting worse by learning oriented to tests or exams. As a result, science as a process, attitude and application are not touched in learning. The learning experience gained is not complete and is not oriented towards the creation of competency standards and basic competencies (Fatmawati & Sujatmika, 2018). Teachers only deliver science as a product while students only receive factual information. Students only learn science at the dominant low cognitive level.

Based on the results of observations made by interviewing teachers and students at MTs Negeri 1 Libureng Bone Regency which shows that students who are developed through learning activities have not really touched the affective and psychomotor aspects. Science learning at the school very rarely does practicum activities and is usually only done once a semester due to the lack of teacher knowledge about practicum activities and the unavailability of a practicum activity guide regarding material that can be practiced so they only do science learning in the classroom so that students sometimes feel bored.

Practical activities that are usually carried out once a semester are only taken from one of the science package books used by the school. The practicum instructions in the existing LKS and modules contain rigid steps that must be carried out by students so that they do not make them creative and still feel confused by the activities carried out. In addition, the practicum instructions only test the theory, while the practicum is to solve students' real-world problems. This causes students to lack problem solving skills. The knowledge gained cannot be used to solve problems faced in everyday life.

Based on the explanation above, the authors plan to develop problem-based science practicum instructions whose contents begin with brief material which is an orientation to the problem to be practiced and then formulate problems that will later be solved by students through practicum activities. The author's hope for the problem-based practicum manual that will be made is to

help develop creative thinking skills and problem-solving skills and help teachers in schools in implementing science practicum activities.

METHOD

Research Type and Design

This research is a *Research and Development* (*R&D) or is a* research and *development using the 4D model by Thiagarajan which consists of 4 steps, namely (1) Define D*) or is research and development using the 4D model by Thiagarajan which consists of 4 steps, namely (1) *Define*, (2) *Design*, (3) *Develop* and *Disseminate*, or adapted 4-P model, namely Defining, Designing, Development, and Dissemination, However, with the limitations of the researchers, the development of this practicum guide only reached the *develop* stage, namely in the revision of the limited trial results, where later it is hoped that there will be other researchers who will be able to continue the results of this development with experimental methods or PTK to find out more about the effectiveness of problem-based practicum instructions that have been developed.

Research Implementation Procedure

This research uses the 4D model by using 3 stages of research in the model, namely:

Define

In the context of developing teaching materials (modules, books, LKS etc.), the defining stage is carried out in a way:

1) Curriculum analysis. In the early stages, researchers need to review the curriculum in force at the time. In the curriculum there are competencies to be achieved. Curriculum analysis is useful for determining which competencies the practicum manual will be developed on. This is done because there is a possibility that not all competencies in the curriculum can be practiced.
2) Analyze learner characteristics. Like a teacher who will teach, researchers must recognize the characteristics of students who will use the practicum manual. This is important because all learning processes must be adapted to the characteristics of students.
3) Material analysis. Material analysis is carried out by identifying the main material that needs to be practiced, collecting and selecting suitable material, and rearranging it systematically.
4) Formulate objectives. Before writing a lab manual, the learning objectives and competencies to be taught need to be formulated first. This is useful to limit the researcher so as not to deviate from the original purpose when writing the lab manual.

Design

In the context of developing teaching materials, this stage is carried out to make a practicum manual with the content framework of the curriculum and material analysis results and simulate the use of the practicum manual that has been made in a small scope. Before the product *design* proceeds to the next

stage, the product design (practicum manual) is then checked by peers and supervisors. Based on the results of the peer review and the supervisor, there is a possibility that the product design still needs to be improved according to the suggestions.

Develop

Thiagarajan divided the development stage into two activities namely: *expert appraisal* and *developmental testing*. *Expert appraisal* is a technique to validate or assess the feasibility of product design. In this activity, an evaluation is carried out by experts in their fields. The suggestions given are used to improve the materials and learning designs that have been prepared. *Developmental testing* is an activity to test the product design on real target subjects. At the time of this trial, data on responses, reactions or comments from target users of the practicum manual were sought. The test results are used to improve the product.

In Developing a practicum manual, *development* activities (*develop*) are carried out with the following steps.

1) Validation of the practicum manual by experts. The things that are validated include guidelines for using the model and learning model devices. The expert team involved in the validation process consists of material experts and teaching material development experts.
2) Limited trial by testing the readability of the product on class VIII students of MTsN 1 Libureng
3) Revision of practicum manual based on trial results

Disseminate

The final stage of the 4D model is the dissemination of the developed product. At this stage, an evaluation is also carried out to ensure that the product developed is truly effective and in accordance with the needs that have been previously identified.

Data Collection Instruments

The whole instrument will be validated by three validators, namely two people as expert validators and one person acting as a practitioner validator. The data collection instruments used in this study are as follows:

1) Learning device validation sheet. This validation sheet is a sheet made by researchers and given to validators to validate questionnaires and problem-based practicum instructions. The purpose of this validation is to obtain a validity and practicality of learning devices.
2) Learning device practitioner sheet. This practitioner sheet is a sheet made by researchers and given to practitioners (science teachers) to assess the level of practicality of problem-based practicum instructions.
3) Student response questionnaire instrument. The student response questionnaire instrument was used to obtain data on students' opinions/responses to the problem-based practicum manual developed.

Data Analysis Technique

Techniques for measuring the validity of media by experts. According to Hobri (2009), based on the data from the media validity assessment results from several experts who are competent in the field of media development, the average value of the indicators given by each validator is determined. Based on the average indicator value, the average value for each aspect is determined. The average value of the total aspects assessed is determined based on the average for each aspect of the assessment. The activity of determining the total average value of the media validity assessment aspects follows the following steps.

1) Recapitulate the media validity assessment data into a table that includes: aspects (Ai), indicators (Ii), and values (Vji) for each validator including media expert validators, material or subject content experts.
2) Determine the average value of validation results from all validators for each indicator with the formula:

$$Ii = \frac{\sum_{j=1}^{n} Vji}{n}$$

where, *Ii*= mean for the *i-th* aspect of the *j-th* indicator,
Vji= jth validator score data on the *i-th* indicator,
n= is the number of validators

3) Determine the average score for each aspect with the formula:

$$Ai = \frac{\sum_{j=1}^{n} Iif}{m}$$

where, *Ai*= mean score for the *i-th* aspect,
Iij= mean for the *i-th* aspect of the *j-th* indicator,
m = number of indicators in the *i-th* aspect

4) Determine the Va value or total average value of the average scores for all aspects with the formula:

$$Va = \frac{\sum_{i=1}^{n} Ai}{n}$$

where, Va= the total mean score for all aspects,
Ai= the mean score for the *i-th* aspect,
n= number of aspects

Furthermore, the Va value or total average value is referred to the interval for determining the level of validity of the practicum instructions can be seen in Table 1. The criteria states that the media has a good degree of validity, if at least the level of validity achieved is a valid level. If the level of validity achievement is below valid, it is necessary to make revisions based on the input (correction) of the validator. Furthermore, validation is carried out again. And so on until a valid media is obtained (Hobri, 2009).

Table 1. Interval for determining the level of validity of the product.

Score interval	Category of Validity
1 ≤ Va < 2	invalid
2 ≤ Va < 3	less valid
3 ≤ Va < 4	valid enough
4 ≤ Va < 5	Valid
Va = 5	very valid

Validity by media experts and practitioners

The same analysis technique to measure validity was also carried out on the assessment of practicality or implementation by practitioners (Biology teachers) of the media based on their perceptions and experiences, but the average value or IP was referred to the media practicality interval as follows:

Table 2. Criteria for categorizing the practicality of practicum instructions.

Score interval	Practicality Category
1 ≤ IP < 2	Not very good
2 ≤ IP < 3	Not good
3 ≤ IP < 4	Sufficient
4 ≤ IP < 5	Good
IP = 5	Very Good

The criteria states that the media has a good degree of validity and practicality, if at least the level of validity achieved is valid and if at least the level of practicality achieved is good. If the level of validity achievement is below valid and the level of practicality is below good, then revisions need to be made based on input and corrections from experts and practitioners.

Techniques for measuring effectiveness

For effectiveness, it is measured by looking at the positive responses given by students by filling out a questionnaire sheet distributed to students. Then the data obtained from the administration of the questionnaire / questionnaire was analyzed by determining the number of students who gave answers worth positive and negative responses for each category asked in the questionnaire by summing and grouping the answers according to the form of instrument used, namely a questionnaire that has five alternative answer choices, namely "Strongly Agree", "Agree" which is on the "Agree" side as a marker of positive student responses, alternative answer choices "Strongly disagree", "Disagree" and doubt which is on the "Disagree" side as a marker of negative student responses. Data on the sum of students who answered positively and negatively were expressed in percent (%). A positive response means that students support, feel happy, are interested in the media used. negative response means the opposite. To determine the effectiveness of the media used in terms of student responses, if the number of students who gave a positive response was greater than or equal to 80% (≥80%) of the number of subjects studied (Hobri, 2009).

RESULT AND DISCUSSION

The development research that has been carried out refers to the 4-D development model. The results of the research implementation stages are as follows.

Define Stage

The results of the defining stage of developing problem-based practicum instructions are as follows. The results of the material analysis of problem-based practicum instructions to determine the first semester science material that can be practiced. The selected materials are growth and development, nervous system, digestive system, respiratory system, circulatory system and structure and function of the growing body, photosynthesis, movement in plants, pests and diseases in plants, household chemicals and addictive and psychotropic substances.

The results of determining the problem formulation for each practicum activity related to what will be achieved can be seen in Table 3.

Table 3. Problem Analysis of Problem-based Practicum Instruction Activities.

Title of practicum unit	Problem Formulation
Germination	1. What is the germination process in kidney beans? 2. How do you know some of the factors that affect germination?
Stages of human development	1. What is the process of human growth and development? 2. What are the stages of human development after birth?
Joint motion	1. How to determine the type of joints in humans?
Nutrients in food	1. How do we know the types of nutrients contained in different types of food?
Human breathing frequency	1. How do you know the frequency of breathing in humans? 2. How do you know some of the factors that affect the frequency of human breathing?
Blood vessels	1. Is everyone's pulse rate different? 2. What factors affect a person's pulse rate?
Blood type	1. How do we know the type of blood type in humans?
Monocot and dicot roots	1. How are monocot and dicot roots different?
Organs in plants	1. Does every plant have roots, stems, leaves and flowers? 2. How are the organs of different plants different?
Amylum test on leaves	1. How to prove that plants photosynthesize?
Tropism motion	1. Is light one of the stimulating factors that affect the direction of motion in sprout growth?
Nasty motion	1. How do you prove that plants can move in a direction that is not influenced by the direction of the stimulus?

Pests and diseases in Plants	1. How do you differentiate between pests and diseases in plants?
Baham household chemistry	1. How are the different chemicals that we often encounter in the household? 2. Do all household chemicals have the same side effects?
Addictive substances in cigarettes	1. How do addictive substances in cigarettes affect the human lungs?

Design Stage

The determination of the title of each practicum unit in the developed practicum instructions can be seen in Table 4.

Table 4. Title of Problem-Based Practicum Manual

Material	N	Title of practicum unit
Growth and development	1	Germination
Growth and development in humans	2	Stages of human development
Motion system	3	Joint motion
Digestive system	4	Nutrients in food
Respiratory system	5	Human breathing frequency
Circulatory system	6	Blood vessels
	7	Blood type
Plant body structure and function	8	Monocot and dicot roots
	9	Organs in plants
Photosynthesis	10	Amylum test on leaves
Motion in plants	11	Tropism motion
	12	Nasty motion
Pests and diseases in plants	13	Pests and diseases in Plants
Household chemicals	14	Baham household chemistry
Addictive and psychotropic substances	15	Addictive substances in cigarettes

The components of the problem-based practicum instructions that have been developed can be seen in Table 5.

Table 5. Components of Problem-Based Practicum Instructions

No	Components Instructions for practicum
1	Brief material / Problem orientation
2	Problem formulation
3	Practicum objectives
4	Tools and materials
5	How it works
6	Evaluation questions
7	Conclusion

Development Stage

This stage aims to produce the final form of the product developed at the planning stage. The results of the development stage are three, namely: 1) Development of problem-based practicum instructions, 2) Products of

practicum instructions, 3) Data on product evaluation results, teacher and student response questionnaires. The data obtained in this research on the development of problem-based practicum instructions consist of data from product evaluation results to test the validity of practicum instructions and data from teacher response questionnaires to test the practicality of practicum instructions and student response results to test the effectiveness of the product.

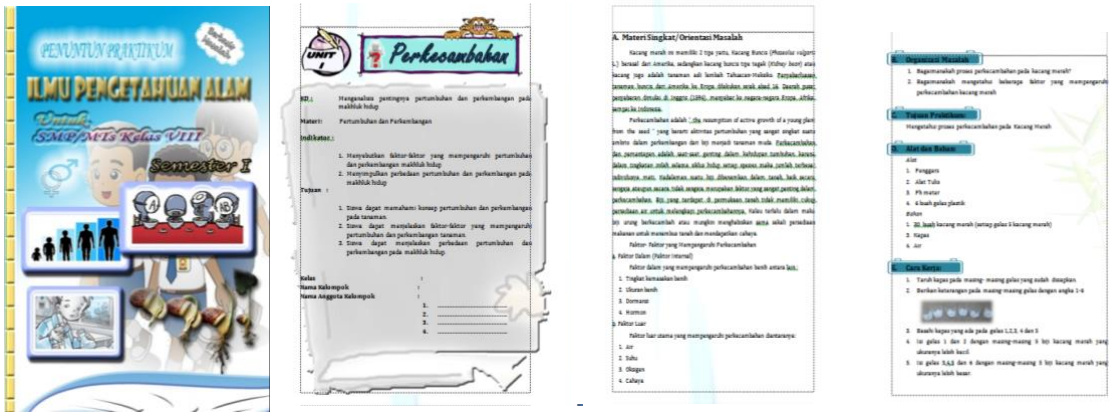

Figure 1. Product design of problem-based practicum guide.

The data from the product evaluation test includes data on the results of product evaluation from two expert lecturers, namely Dr. Muhiddin, M.Pd and Andi Rahmat Saleh S.Pd, M.Pd. This product evaluation data is to test the validity of the practicum instructions. This evaluation data includes an assessment of the aspects of the suitability of the practicum instructions format, aspects of content feasibility, language and writing aspects which are converted into four categories, namely very valid, valid, less valid and invalid.

Data Analysis of Validity

The results of data analysis the validity level of the developed science practicum instructions can be seen in the following table

Table 6. Results of validity test.

Component	Average	Results
Format	4	Valid
Contents	4	Valid
Language and Writing	4,6	Valid
Total	4,2	Valid

Practicality Data Analysis

The results of the assessment of the level of practicality by two science teachers at MTs Negeri 1 Libureng Bone who acted as practitioners can be seen in Table 7.

Table 7. Results of practicality analysis of problem-based practicum instruction.

Respondents	Teacher 1	Teacher 2
Total	43	40
Average of each indicator	41,5	
$IP = \frac{\sum_{i=1}^{n} Ai}{n}$	4,6	**Practical**

Effectiveness data analysis

The data on the results of student responses in class VIII MTs Negeri 1 Libureng Bone Regency can be seen in Table below.

Table 8. Student Response Results.

Indicator	STS	TS	R	S	SS	Percentage	
The use of the practicum guide helps me carry out practicum activities			**(3) 11 %**	**(14) 50 %**	**(11) 39 %**	**89%**	Positf
The presentation of questions in the practicum guide helps me understand the objectives of the practicum activities.			**(1) 4 %**	**(18) 64 %**	**(9) 32 %**	**96%**	Very positive
The problems contained in the guide motivate me to do science practicum activities.			**(8) 29 %**	**(13) 46 %**	**(7) 25%**	**71%**	Positive
The tools and materials listed in the guide are available in the school or around the school environment.		**(1) 4 %**	**(4) 14 %**	**(13) 46%**	**(10) 36%**	**82%**	Positive
Problem-based practicum guides help me solve problems in practicum activities.		**(1) 4 %**	**(3) 11 %**	**(12) 43%**	**(12) 43%**	**86%**	Positive
The problem-based practicum guide encourages me to be active in practicum activities	**(1) 4 %**		**(4) 14%**	**(15) 54%**	**(8) 29%**	**82%**	Positive
With a problem-based practicum guide, practicum activities will be carried out.			**(3) 12 %**	**(15) 54%**	**(10) 32%**	**88%**	Positive
$Rs = \frac{\sum_{i=1}^{n} Rsi}{n}$				**84,8 %**	**Positive**		

Discussion

The quality of practicum instructions includes three components, namely validity, practicality and effectiveness. In testing the product validity of problem-based practicum instructions, through several improvements from the initial product made, these improvements are in accordance with the suggestions of expert validators which include improving the cover which is still less attractive, the observation table which is still incomplete, the formulation of problems that must be improved again and the use of language and writing that must be improved. After making improvements according to these suggestions, this problem-based practicum instruction product was declared usable with minor revisions. Based on the results of data analysis of expert and practitioner assessments as described in the presentation of validation results, in general the practical instructions developed have met the validity criteria. In this case it can be explained that the practicum instructions that have been developed have been based on strong theoretical studies and have internal consistency. This interpretation is based on the acquisition of data on the validity of the validated practicum instructions in the interval $3 \leq VR \leq 4$, in the valid category.

This aspect consists of sub-aspects (1) the title of the material represents the entire content of the practicum instructions, (2) the activity instructions are able to direct students in practicum activities, (3) present the competencies to be achieved, (4) the suitability of supporting information in the form of a brief theory of tools and materials, ways of working and concepts to be discussed in the practicum instructions, (5) the suitability of procedural steps of activities that must be carried out by students with concepts to be discussed in the practicum instructions, and (6) the suitability of the presentation of questions with activities carried out in accordance with the practicum instructions.

The content aspect of the practicum instructions consists of sub-aspects (1) the suitability of the indicators to be achieved, (2) the truth of the concept or material, and (3) the suitability of the material to the practicum activities. For the first sub-aspect, the first validator gave a score of four while the second validator gave a score of two, the second sub-aspect, the first validator gave a score of four while the second validator gave a score of three, and for the third sub-aspect, the first validator gave a score of four while the second validator gave a score of two. The average score for the content aspect of the practicum instructions is 4 or valid.

The language and writing aspect consists of sub-aspects (1) the questions are formulated in simple language and do not cause double interpretations, (2) are written using standard Indonesian language rules, and (3) use clear and understandable letters. Based on the results of data analysis of the validity of problem-based practicum instructions, the validity value of two expert validators for each assessment aspect, namely format suitability is 4; content feasibility is 4; language and writing are 4.6 So the average value of the validity of problem-based practicum instructions is 4.2 so it can be concluded that this value is included in the "Valid" category (4). $\leq V < 5$). The validity of problem-

based practicum instructions is concluded to be included in the valid category because the problem-based practicum instructions that have been made fulfill all aspects of the assessment.

The practicality component of the practicum instructions is determined based on the assessment by two practitioners who are assessed in general based on their knowledge and experience as practitioners and based on the results of observations of the implementation of the practicum instructions during the practicum process in the laboratory.

1) Interesting Guiding Design Components
2) The illustration component of the picture is in accordance with the material.
3) Components The lab guide is easy to carry.
4) The Instructions component provides clear and easy-to-understand instructions
5) Components The size and typeface used are easy to read.
6) The brief material component provided helps students to better understand the purpose of the practicum.
7) Components Presentation of material and problem orientation in the guide encourage students to solve problems or find answers to problems from practicum activities.
8) Component Presentation of material encourages learners to search, gather information and other findings to find out/prove the truth of a fact then make conclusions in their own language.
9) Component Presentation of material encourages learners to actively participate in discussions with other learners and the teacher.

According to Prastowo (2011), the practicality of a teaching material can only be fulfilled if experts and practitioners state that what is developed can be applied. The practicality of problem-based practicum instructions is seen from the results of the teacher's response. In the large Indonesian dictionary, practical means easy and happy to use it. The indicator of the practicality of problem-based practicum instructions is the result of the teacher's response as a practitioner of problem-based practicum instructions.

The results of the data analysis of the teacher response questionnaire on problem-based practicum instructions for all aspects of the assessment, namely the attractiveness of the appearance of the practicum instructions, ease of use, ease of understanding the contents of the practicum instructions, presentation of learning materials, namely 4.6. Based on the data obtained, the criteria for the practicality of problem-based practicum instructions fall into the "very practical" category (4.6). $\leq P < 5$).

The practicality of problem-based practicum instructions is concluded to be included in the very practical category because the problem-based practicum instructions that have been made meet the practicality aspects based on the results of the analysis of teacher responses which show positive results in the agree category. Based on the total practicality value of the practicum instructions, the problem-based practicum instructions are declared practical

and feasible to use at MTs Negeri 1 Libureng, Bone Regency. The practicality of practicum instructions is important to test because practicality is one of the criteria that determine a development product is said to be good and feasible.

The practicum guide is said to be effective, if it meets two criteria, namely (1) the practicum guide developed is effective according to experts and practitioners; (2) the practicum guide developed can provide results in accordance with expectations. The effectiveness indicators are (1) students' activities in practicum activities, (2) teachers' ability to manage the class during practicum activities, and (3) students' responses. The criteria for the effectiveness of practicum instructions are met if 2 of the 3 components that determine the effectiveness of the syrata have been met.

Measurement of the effectiveness of problem-based practicum instruction products that have been developed is measured only by using data on the results of student responses to the practicum instructions that have been developed. Data on the results of student responses conducted by distributing questionnaires to students on problem-based practicum instructions is the average percentage of student responses to the overall content of problem-based practicum instructions is 84.8% of students who gave positive responses and students who gave negative responses as much as 15.1%. This shows that almost all students gave a positive response to this problem-based practicum guide, because they considered that this practicum guide could further improve their understanding of science material in practicum activities and was very helpful in carrying out practicum activities.

The data obtained from the distribution of student response questionnaires shows that this problem-based practicum guide has met the effectiveness criteria based on the positive responses given by students. According to Hobri (Rahmayani, 2015), to determine the achievement of learning objectives in terms of student responses, if the number of students who give a positive response is greater than or equal to 80% of the number of subjects studied.

CONCLUSION

Based on the results of research and discussion, it can be concluded that the problem-based practicum instructions developed are valid, practical and effective. The validity value is 4.2 which means that the problem-based practicum instructions are included in the valid criteria. The practicality value is 4.6 which means that the problem-based practicum instructions are classified as practical criteria. The problem-based practicum instructions developed have also been classified as effective by looking at the results of positive responses from students which reached 84.8%.

REFERENCES

Agustina, M. (2018). Peran laboratorium ilmu pengetahuan alam (ipa) dalam pembelajaran ipa madrasah ibtidaiyah (mi)/sekolah dasar (sd). *At-Ta'dib:*

Jurnal Ilmiah Prodi Pendidikan Agama Islam, 1-10.

Agustina, P., Saputra, A., Anif, S., Rayana, A., & Probowati, A. (2021). Analisis keterampilan proses sains dan sikap ilmiah siswa kelas XI IPA SMA pada praktikum biologi. *EduSains*, *13*(1), 1-7.

Arifin, Z. (2020). Metodologi penelitian pendidikan. *Jurnal Al-Hikmah*, *1*(1).

Fatmawati, E. T., & Sujatmika, S. (2018). Efektivitas Pembelajaran Problem Based Learning Terhadap Hasil Belajar IPA Ditinjau Dari Kemampuan Berpikir Kritis. *Wacana Akademika: Majalah Ilmiah Kependidikan*, *2*(2), 163-171.

Hidayat, U. S. (2021). *Urgensi Penguatan Pendidikan Karakter Dalam Menyiapkan Generasi Emas 2045: Strategi Membangun Generasi Cerdas, Berkarakter dan Berdaya Saing di Abad 21*. Nusa Putra Press.

Lestari, N. (2018). Prosedural mengadopsi model 4D dari Thiagarajan suatu studi pengembangan LKM bioteknologi menggunakan model PBL bagi mahasiswa. *Jurnal Teknologi*, *1*(1), 56-65.

Moiyo, Y., Buhungo, T. J., & Abdjul, T. (2024). Analisis Keefektifan Perangkat Pembelajaran Model Problem Based Learning (PBL) Berbantuan Video Pembelajaran Materi Fluida Statis. *Jurnal Jendela Pendidikan*, *4*(02), 125-132.

Rahmat, I., Hatta, A. A., Samputri, S., & Nurhidayah, N. (2024). Validitas dan Praktikalitas Media Diorama Berbasis AR (Augmented Reality) berbantuan Assembler Edu pada Materi Siklus Air. *Jurnal Bioedukasi*, *7*(1), 404-410.

Rohman, P. N., Na'im, M., & Sumardi, S. (2021). Pengembangan media berbasis prezi pada mata pelajaran sejarah kelas X SMA dengan model 4d. *JINoP (Jurnal Inovasi Pembelajaran)*, *7*(1), 1-9.

Rosmalinda, D., & Pamela, I. S. (2023). Pengembangan Modul Elektronik Praktikum IPA menggunakan Aplikasi Canva dan Flip Builder. *Pendas: Jurnal Ilmiah Pendidikan Dasar*, *8*(1), 778-789.

Santi, I. K. L., & Santosa, R. H. (2016). Pengembangan Perangkat Pembelajaran menggunakan Pendekatan Saintifik pada materi pokok geometri ruang SMP. *Jurnal Pendidikan Matematika*, *11*(1), 35-44.

Saputra, H. (2021). Pembelajaran berbasis masalah (problem based learning). *Jurnal Pendidikan Inovatif*, *5*(3), 1-9.

Sihotang, N. T. S., Hasratuddin, H., & Yumiati, Y. (2023). ANALISIS KEVALIDAN PERANGKAT PEMBELAJARAN BERBASIS MODEL MISSOURI MATHEMATICS PROJECT UNTUK MENINGKATKAN KEMAMPUAN PEMECAHAN MASALAH DAN MOTIVASI SISWA SD. *Pendas: Jurnal Ilmiah Pendidikan Dasar*, *8*(2), 5004-5018.

Wahab, M. N. N. D., Istyadji, M., & Putri, R. F. (2021). Pengembangan modul pembelajaran IPA SMP berbasis literasi sains pada materi sistem tata surya. *Jurnal Ilmiah Pendidikan Fisika*, *5*(3), 278-291.

Wisudawati, A. W., & Sulistyowati, E. (2022). *Metodologi pembelajaran IPA*. Bumi Aksara.