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Practical design for vibration concepts based on problem based learning to improve science process skills

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Abstract

This research is important to carry out the learning achievements (CPL) of the mandatory physics education study program in developing 21st-century skills, especially science process skills (KPS). The current practicum in the physics education study program at FKIP UMMAT has not been able to train and improve students' KPS properly because the design of practicum activities has not been based on science processes and problem-based learning (PBL). This study aims to design a practicum program for the concept of Vibration as outlined in the form of practicum participant activity sheets (LKPR) and KPS assessment instruments with the target of improving the science process skills (KPS) of physics education students. The method used is Research and Development (R&D) through the ADDIE (Analysis, Design, Development, Implementation, Evaluation) process which begins with analyzing problems, needs, and solutions; designing LKPR and assessment instruments, then validating and testing on a small scale and evaluating the product for further revision and implementation. Quantitative data of the KPS pretest and posttest were analyzed using inferential statistics and normalized gain test to determine the category of KPS improvement using Ms. Excel and IBM SPSS v.23. The practicum design has the characteristics of applying a problem-based model, oriented towards laboratory investigation activities, using traditional musical instruments and computer-smartphone technology devices through three phases and six stages. The practicum program has had a significant impact in improving students' KPS which shows a substantial increase in all aspects of KPS. With the increase in KPS, students can think logically and solve problems.

Keywords: PBL practical design; LKPr; PPP measurement instruments; practical innovation

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INTRODUCTION

Learning principles in the 21st century era orientate the formation of human resources (HR) who have science process skills (Gunawan et al, 2018; Usmeldi, 2019), this is also applied as one of the formulations of learning outcomes (CPL) for the FKIP UMMAT physics education study program namely oriented towards students' scientific skills and creativity. Physics practicum, one of which is the concept of vibration, is one of the appropriate lecture materials for developing students' science process skills

(Sitepu et al, 2021), so that through practicum learning students' competencies and skills need to be trained.

The problem in the field to date is that students' KPS has not shown significant changes as an outcome of the expected practicum function, while practicum is a mandatory subject based on expertise and skills. The reason is that the practicum design implemented is still conventionally oriented towards concept verification (Saputra et al, 2020). The weak KPS of physics education students can be seen from the research results of Ratnasari, et al (2018), Nugraha, et al (2018), Ichwanah & Nurita (2018), Magfirah, et al (2019), Sholihah, et al (2020), and Indri, et al (2020) stated that the practicum learning process uses the method of presenting finished knowledge and does not give students the opportunity to think through investigative activities, only discussing facts, concepts and laws based on what is written in books/dictates/modules/slides and Lectures are the cause of students not being trained in KPS (Lumbantoruan et al., 2019). On the other hand, there is less use of technology to support practicum activities (Subali et al., 2015). This is also supported by information that the learning facilities supporting practicum activities (practicum equipment) in the basic physics laboratory at Muhammadiyah University of Mataram have not been developed with a KPS-based, contextual model and assisted by computer or smartphone technology, and have not been oriented towards developing student KPS (Anwar et al. ., 2018).

Although this has been done by previous research, there has been no significant development experienced by students and physics education laboratories FKIP UMMat to continue to develop and use technology-based practicum for the development of student KPS. Because as long as the practicum carried out by students is not oriented towards science process skills and technology-based many students do not have the expertise and skills of problem solving and critical thinking.

The Problem Based Learning (PBL) model in physics practical learning is an activity that involves procedural and cognitive aspects to discover facts, concepts, principles or laws, to create a product or solve problems (Khery & Khaeruman, 2018). Therefore, basic physics practicum activities need to develop and apply problem-based learning (PBL) tools to improve the skills of prospective physics teacher students. Procedural and cognitive knowledge are two things that are interrelated (Khery & Khaeruman, 2018), likewise scientific knowledge and KPS have a simultaneous correlation with creativity (Zainuddin et al., 2020).

Science process skills (KPS) are skills that must be possessed by all students, and the way to be able to improve science process skills (KPS) by utilizing technology in practicum activities. Based on field observations that the science process skills of physics education students are still low, this research needs to be done. This research can be focused through research questions: (1) how can the syntax of practicum learning on vibration concepts support student KPS?, (2) how does student KPS increase after applying the practicum method developed?, (3) what are students' perceptions/responses to the practicum method what was developed?, and (4) what are the advantages and limitations of the practicum that was developed?.

The aim of this research is to design a practicum program for Vibration concepts which is outlined in the form of practicum activity sheets (LKPr) and KPS assessment instruments with the target of improving the science process skills (KPS) of physics education students.

METHODS

The purpose of this research is to use the Research and Development (R & D) method through the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model as shown in Figure 1, which begins with: (1) Analyze problems, needs, and solutions. Analysis activities are carried out by field observations directly carried out on Physics Education students of FKIP UMMat who are conducting practicum activities by observing and interviewing the results of document observations in the form of notes on interview results to identify materials that are by the learning outcome standards and student graduate profiles, as well as identifying laboratory facilities needed in the development of devices; (2) Designing the syntax of practicum implementation involving technology in the form of computers and smartphones by utilizing of traditional musical instruments, designing LKPr, namely making practicum worksheets that contain PBL-based vibration concepts oriented to science process skills, and assessment instruments; (3) Develop LKPr, as well as science process skills assessment instruments. Furthermore, validation is carried out by expert validators (assessment and evaluation experts, media experts, and physics material experts, and physics learning and experiment experts) until the product meets the eligibility criteria, and small-scale trials are conducted by students together with physics education lecturers to evaluate the product for revision.

The instruments developed for data collection were in the form of questionnaires and rubrics for LKPR assessment, KPS assessment rubrics, then developing questionnaires to explore student perceptions; (4) apply valid devices in a small-scale trial stage involving 5-8 students, based on the trial results that the tool still needs to be revised, the device used has not been able to focus on syntax; (5) evaluate the tools for further revision and implementation. The initial form of evaluation is based on the results of small-scale trials devoted to the practicality of the device and syntax which refers to weaknesses, deficiencies and various obstacles still faced by students, which are then reflected back to continue improving the device. Furthermore, the appropriate practicum tools and programs are disseminated in the SINTA accredited scientific journal.

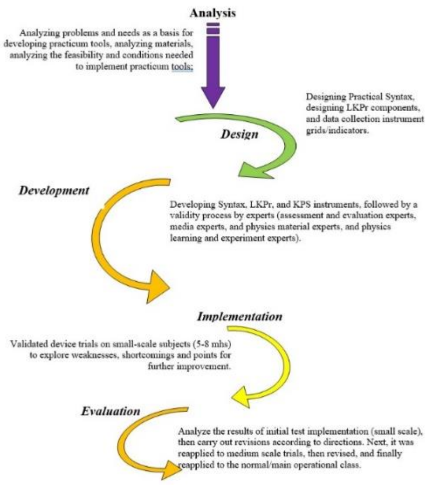

Figure 1. Flow of practical development of the Vibration concept using the ADDIE model.

After all the devices were developed, a medium-scale trial was carried out again on 15 physics education students. Then an evaluation and reflection is carried out, which is then determined as a final and valid tool that can be applied on a large scale/operation to prospective physics teacher students.
Data analysis for the device was carried out using descriptive statistics to obtain scores from validators associated with eligibility criteria. Meanwhile, the analysis of the feasibility of the PPP data collection

instrument is carried out by testing validity and reliability first. Increasing student skill attainment will be determined by the Ngain formula (Hake, 1998). The form of student KPS is determined using a performance assessment rubric which is analyzed descriptively based on science process skills criteria. Students' perceptions/responses to the practical tools were processed descriptively to see trends in students' responses to the implementation of the tools, meanwhile the assessment of students' work products was assessed using a product assessment rubric.

RESULTS AND DISCUSSION

Preliminary Study

Preliminary study activities are an analysis of problems, needs and solutions carried out by field observation and document observation to identify material that is in accordance with learning achievement standards and student graduate profiles, as well as identifying laboratory facilities needed for device development.

Initial study findings include that the vibration-wave learning/teaching system has not yet led to the development of creative thinking (HOTs), is dominated in the form of lectures and is oriented towards mathematical theoretical knowledge, teaching materials/materials are not contextual/not directly related to students' daily experiences -days, vibration-wave phenomena in rope systems and air columns are rarely discussed in laboratory activities. The teachers stated that laboratory investigation activities were very time-consuming and had minimal ability to design practicum activities and use practicum tools, the practicum guidebook model was still a cookbook and the aim of the practicum was only as verification.

Science process skills (KPS) are still very weak because various aspects of KPS are rarely taught or trained at elementary level students. The low level of students' science process skills was also described by Insih, et al (2011) who only achieved an average of 48.66% in the aspects of observation, classification, variable identification, variable analysis, prediction, hypothesis, designing research, making tables and graphs, measuring, and conclude.

Practical Activity Design

This practicum program is characterized by student-centered learning, has three main phases with six stages and various scientific learning experiences, is oriented towards a problem-based learning (PBL) model, involves the use of local resources as learning resources as well as computer and smartphone technology devices as The data acquisition system, which is guided by the student activity sheet (LKM), is shown in Figure 2.

Phase I is a training activity for learning support materials, phase II is a learning activity for core material consisting of organizing, investigating, presenting and mentoring. Meanwhile, phase III is a problem solving activity. It is very important to carry out training activities to introduce and understand the basic definitions of KPS aspects, computer and smartphone-based software and applications and practice using ICT devices that can be applied in learning vibration, wave and sound material. This is in line with the statement of Firdaus et al, (2020) that the existence of training activities in a learning model is important. The training activities as a first step, so that students understand in general the activities that will be carried out.

The organization of learning activities is intended to provide order between lecturers and students in discussing material according to the breadth and depth of study. Students are expected to be able to respond or explain challenging questions from lecturers both regarding material they have studied and those they will study as stimulus, including understanding symbols and terms related to the concepts being studied. In the organizing stage the lecturer and a group of students were also jointly involved in presenting and observing videos of the vibration sources of musical instruments. The lecturer asked several questions such as "Is there a relationship between the length of the string stretched on a gambo musical instrument, how much does the frequency of the note sound change, and students are asked to develop the concepts of period, amplitude, string tension, string density, and wave propagation speed," as follows. Also given is a problem that will be sought by the student group. The presentation of situations, phenomena and problems can encourage student involvement in scientific arguments so that they will articulate ideas, understand complex phenomena and engage in scientific discourse (Firdaus et al, 2020). In this phase, the ability of students has increased, for phase 1 students only have a general understanding. While in the organizing activities, students already know how musical instruments work in the learning concept.

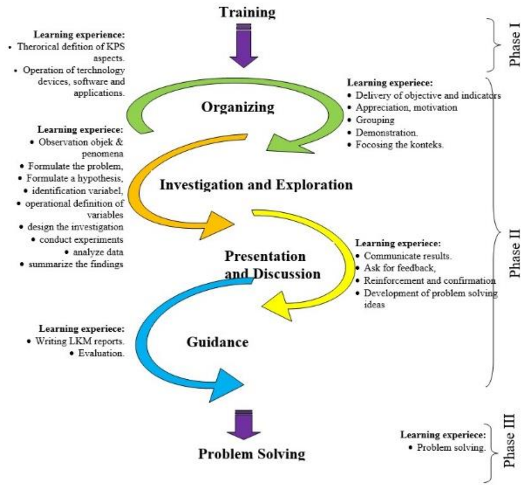

Figure 2. Phases and Stages of the Vibration-Wave Practicum Program PBL based

Investigation is the main activity centered on students with a science process that focuses on collecting and interpreting data in groups to construct concepts/principles/laws based on measuring the required variables. Students carry out controlled investigations (controlling one variable, for example the tension force of a string) and vary the length of the string then measure the appropriate frequency to verify the predicted mathematical model and find a meaning/form of the constant of proportionality (c). In this phase, students not only have the ability to understand the concept of science process skills but can build their concepts. This is by the results of the research Hardianti & Kuswanto (2017), With this step, students can have the opportunity to build concepts and master concepts and form KPS gradually (Hardianti & Kuswanto, 2017). The involvement of real media and the assistance of computers/smartphone applications can improve aspects of KPS hypothesis, investigation and communication (Gunawan et al, 2019). Hermansyah et al, (2019) stated that the PBL model through experimental activities can help students develop knowledge of analysis, evaluation and creation. The same thing was also expressed by Riantara, et al, (2019) that the experience of laboratory activities can develop understanding of concepts and scientific skills . According to Cagande & Jugar (2018), understanding graphics is considered an important skill, therefore this practicum program specifically emphasizes the KPS aspect of graphic literacy because with graphics the concept of vibrations and waves becomes easy to present and understand.

The findings are reported in class through presentation activities and discussing various procedures, concepts and problems encountered to get feedback, confirmation and reinforcement so that each student gets complementary (constructive) information and knowledge. Presentation and discussion activities can practice communication skills and develop a cooperative attitude because at this stage there is interaction between students, including the lecturer as facilitator. After facts, concepts, principles and laws are identified and determined according to scientific truth, the lecturer then facilitates students to discuss building ideas and identify/classify creative ideas to solve problems.

Considering that not all material and topics are studied directly through investigation by each group of students and there is limited time, the program design includes a mentoring/mentoring phase to provide students with the opportunity to consult and discuss the material that has been studied during phase II in order to receive direction and correction. , and reinforcement regarding problem solving.

The principles of this lecture program are in accordance with the model recommended by Wenning which is based on practical activities that can develop high-level thinking skills of prospective physics teachers (Wattimena, Suhandi, & Setiawan, 2014) which is also identical to the SETS (Science Environment Technology and Society/Science) learning model , Environment, Technology and Society) which can make learning more active, increase KPS, give students a mindset to look at things in an integrative way, so they can apply them creatively to solve problems in everyday life (Sarjono, 2020).

Achievement Results of Increasing Science Process Skills (KPS)

The KPS aspects that experienced the highest/strongest improvement in the trial class were KPS-6/variable identification (0.740), KPS-9/building tables (0.792), and KPS-10/building graphs (0.826). A practicum program designed based on PBL can have a significant influence on increasing the KPS of prospective physics teacher students.

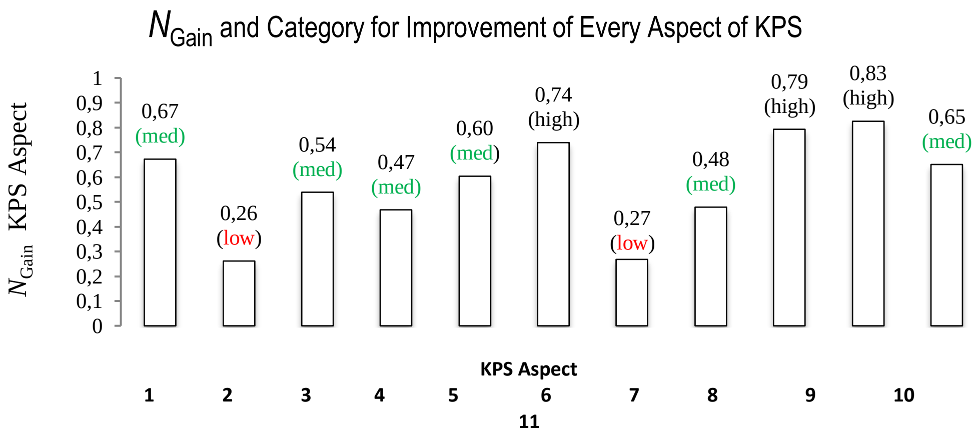

Figure 3. NGain and Improvement Categories for Every Aspect of KPS.

The implementation of the wave lecture program appears to be more effective in developing the science process skills of prospective physics teacher students, and also has a good impact on improving students' science process skills. This is in line with the results of Noviyanti's research (2023), which show that the increase in basic KPS can also be seen from the N-Gain value of 0.615 with a moderate category. Then, students' responses to PBL activities to improve basic KPS on vibration material can be seen from the average percentage of scores on students of 86.08%, so the criteria for implementation can be categorized with a very high categor (Januareva 2023) .Several efforts made by lecturers and students to support the smooth implementation of this vibration-wave practicum program include the involvement of traditional musical instruments and ICT media. The training program is specifically intended to introduce ICT tools, models and learning activities that will be applied to the designed practicum program, as well as to enable students to familiarize themselves with activities based on scientific processes and practice procedures for data collection and analysis of experimental data using computers to discover a concept. In this training program, students are given a review of material regarding the concepts and principles of the science process and aspects of their skills, review and strengthening the use of the Ms. Excel, which has been used for data and graph analysis activities, is also introduced with new software for students to manage and analyze more advanced graphs, namely LoggerPro, while to support all data acquisition activities, students are introduced and trained to use and explore various software or applications. computer and smartphone-based freeware involved in lecture programs.

Students experience experimental/laboratory investigation-based learning activities guided by PBL-based LKM, software-based learning media and ICT applications. The process of learning activities for experimental group students is student-centred in collaborating with the class lecture model and the investigation/experiment activity model to explore vibration-wave phenomena. Starting with discovery learning activities, interactive demonstrations and inquiry learning to holding discussions to observe and study various wave phenomena that occur on traditional musical instruments, then students carry out investigative activities using scientific processes to answer and resolve various problems and communicate the findings in the discussion stage class.

Investigation activities are carried out in groups and guided by an LKM which is prepared based on the PBL model so that it guides the process of finding students' concepts and KPS. The various statements and questions in the LKM are productive in nature which can stimulate and direct students to carry out further investigations in a structured manner, apart from that they can provide feedback to students to understand the procedures that have been carried out which require evaluation and improvement. Data collected through investigations is required to obtain data that is logical and in accordance with empirical facts or concepts even though precision and accuracy are not required, therefore the data collection process stage requires the involvement of lecturers as controllers.

Reports on the results of investigative activities in the form of LKM are also used as evaluation material for lecturers to obtain an overview of the science process skills and understanding of concepts achieved by student groups and to determine the obstacles and difficulties that students are still experiencing. Rahmawati Kartikaningsih (2021), The results of statistical tests show significant differences in pretest and post-test scores on concept understanding and KPS assessments. From the results of the practicality and effectiveness tests, it can be concluded that the learning devices are practical and effective to use to improve students' understanding of concepts and science process skills (KPS) (Kartikaningsih and, Nurlansi 2021).

Results of Practical Design Perception

In general, student responses to the practicum program designed to solve fundamental problems related to vibration-wave phenomena are very positive with an average score for all aspects of 399.91/S (max. 500). The aspects observed in students' perceptions of the practicum program consist of aspects of motivation, benefits and use, effectiveness and efficiency, attractiveness, attitude, convenience, knowledge development, development of science process skills, novelty and ICT literacy.

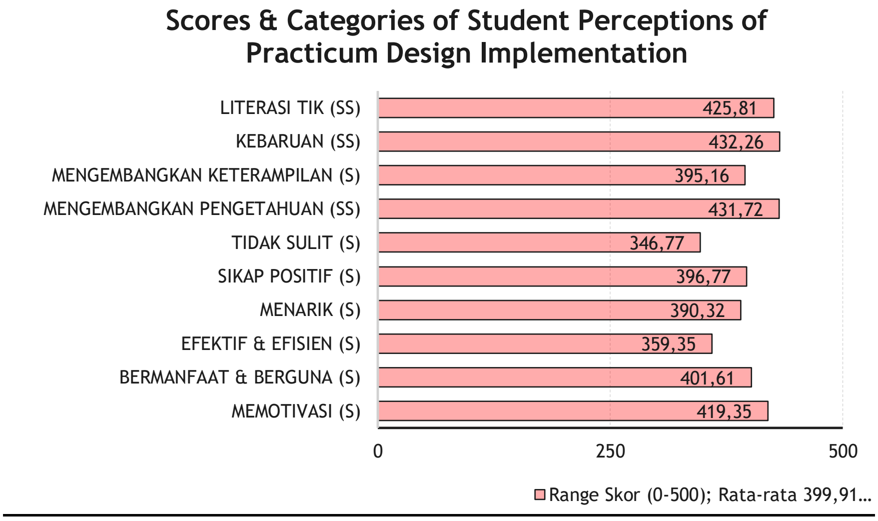

Figure 4. Student Perception Scores and Categories in the PBL-Based Vibration-Wave Practicum Program.

The majority of students gave positive responses to the practicum program assisted by traditional musical instruments and the ICT applied. Practicum of vibrations and waves associated with traditional musical instruments can provide students with motivation and interest in learning, apart from that, students can get to know the various types and acoustic characteristics of traditional musical instruments through physics learning with various visual representations of wave forms directly and in real time as well as involving and activating all student senses.

CONCLUSION

Based on the research results, it was concluded that the practicum design had the characteristics of implementing a problem-based model, oriented towards laboratory investigation activities, using traditional musical instruments and computer-smartphone technology devices through three phases and six stages, namely training, organizing, investigation/exploration, presentation and discussion, guidance/strengthening, and problem solving. The practicum program has had a significant impact in increasing student KPS, showing a significant increase in all aspects of KPS. Furthermore, students gave positive responses to the practicum program because it was in line with students' learning expectations as future physics teachers.

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