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Need Analysis of Pre-Laboratory Development to Support Experimental Activities in Science Learning

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Abstract: The purpose of this study was to identify the implementation of the experimental method in science learning and the obstacles faced by teachers, as well as to identify the application of pre-lab in science learning. Research design was survey which is non-experimental quantitative research. The participants were 26 teachers who teach subjects in the sciences, namely Chemistry, Biology, Physics, and Science as integrated subjects. Data were collected through online questionnaires using google forms and were analyzed descriptively. The results show that experimental activities have not been fully applied to science learning. Most teachers provide the tools and materials needed in learning activities in the laboratory and provide work procedures to students. The constraints that are faced by teachers in applying the experimental method are related to facilities and infrastructure, student characters, and experiment time allocation. Most of the teachers have also carried out pre-lab activities, but they are still dominated by lectures from the teacher. This study also explored the pre-lab model to be developed, almost all teachers agreed if the pre-lab was developed in the form of virtual learning. The forms of media that teacher's interest in for pre-lab activities are videos and android applications.

Keywords: Experiment; Pre-lab; Sciences learning

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Introduction

Experimental activities are one of the main activities in science learning. The experimental method provides an opportunity for students to prove themselves about a question or hypothesis being studied (Hastuti & Hidayati, 2018). Experiments are designed to help students carry out scientific investigation activities by emphasizing the discovery process, being able to improve communication skills (Seery et al., 2017), and being able to solve problems creatively and effectively. The experimental method is very suitable to be applied to teach science process skills, especially those that require psychomotor skills, such as the use of tools (Widodo, 2021). In addition, experimental activities can also increase interest, critical thinking skills and curiosity.

However, the implementation of experiments so far has not shown optimal results in accordance with the objectives that have been described. Many factors which could be the cause of this failure, one of them is the lack of effective and efficient learning strategies. For example, students are accustomed to doing experiments in the laboratory using a cookbook or given a worksheet containing the objectives and working procedures, so that they are not able to build concepts. They are used to conducting laboratory activities through a step-by-step protocol that encourages students to carry out experiments without thinking about what they are doing or why they are doing it.

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In addition, teachers consider that experimental activities that are in accordance with their nature cannot be carried out at the secondary school level because of the diverse abilities of students and the limited time allocation for laboratory activities. They often found it difficult when they are asked to formulate problems and hypotheses and design practical procedures. In addition, these activities require a lot of time to prepare, and the level of student independence is also still low. So that in the end, the laboratory activities are still directed to traditional strategies and students only do the verification.

Laboratory activities that use the cookbook method are indeed quite successful in imparting facts, rules, procedures, theories, and algorithms from science domain. But in the long run, this method is sufficient to help students refine and construct their ideas about science concepts because they do not display higher order thinking skills or metacognition (Imaduddin & Hidayah, 2019). In addition, such methods limit students' growth as scientists and can make it difficult for students to turn to the expectations of a research laboratory experience (Boyd-Kimball & Miller, 2018). Consequently, students are not able to develop science process skills (SPS) as one of the skills mandated in the science curriculum in Indonesia. SPS can promote by active learning method such as problem solving (Saputro et al., 2019; Seyhan, 2015), discovery learning (Astuti, 2019; Bahtiar & Dukomalamo, 2019; Nirmala & Darmawati, 2021), and inquiry (Adnyana & Citrawathi, 2017; Aktamiş et al., 2016; Demircioglu & Ucar, 2015; Ekici & Erdem, 2020). However, these methods have not been applied optimally because of the student's readiness factor.

One way to overcome readiness problem is to use the preparatory activities before students enter the laboratory. Student preparation is the key of success in learning, as in laboratory activities which is considered as a complex learning environment (Spagnoli et al., 2019). This preparatory activity is known as pre-laboratory (pre-lab). This activity is a common thing to do in science learning. Based on several studies on pre-lab, all of them show positive findings for learning activities, even this pre-lab supports the application of flipped learning (Seery, 2015). Pre-lab increase the scores of student's assessment (Rodgers et al., 2020). Pre-lab also have good impact in student performance by minimize mistake in experimental work and promoted accuracy and precision of chemical preparation (Sarmouk et al., 2020).

The framework for the design of pre-lab activities is in line with the principles of cognitive load theory (Agustian & Seery, 2017). There are two principles of the framework: supporting students in complex scenarios and providing the information needed to complete assignments. The relevance is the nature of information provided beforehand and given in the exact time, which is characterized as supporting and procedural information.

In this study, a needs analysis was carried out on the development of pre-labs to support the implementation of experimental activities in science learning. Science learning in question is not only limited to junior high school science subjects, but also includes chemistry, biology, and physics subjects taught in high school or vocational high school. In particular, the purpose of this study is to identify the implementation of the experimental method in science learning and the obstacles that are faced by teachers, as well as to identify the application of pre-lab in science learning.

Method

This study uses a survey research design which is non-experimental quantitative research. A survey design can be used to provide a quantitative description of trends, attitudes, and opinions of a population (Creswell & Creswell, 2018). In general, there are two things revealed through this survey, first, this research reveals the condition of laboratory activities that have been carried out in schools and secondly, to find out the opinions of teachers regarding pre-lab activities.

Participants in this study are 26 people who are teachers who teach subjects in the sciences, namely Chemistry, Biology, Physics, and Science as cohesive subjects. The demographics of the participants are shown in Table 1.

Table 1. Participants of the study

Types	Category	Frequency	Percentage (%)
Education level	SMP	15	57.70
	SMA	6	23.10
	SMK	5	19.20
Subject	General Science	14	53.80
	Physic	2	7.70
	Chemistry	9	34.60
	Biology	1	3.80
Length (experience) of teaching	Less than 5 years	8	30.80
	5 – 10 years	3	11.50
	More than 10 years	15	57.70

Data was collected through online questionnaire using a google form. Data collection was carried out in November 2021. The questionnaire that is used was semi-open and consisted of 14 questions. The data were analyzed descriptively, by summarizing and analyzing the data that had been collected to provide an overview of the conditions and situations that occurred in the field.

Result and Discussion

Experimental activities are an important method in science learning. This experimental method aims to train students' abilities in finding and collecting various answers for the problems they face by conducting their own experiments (Haerani, 2018). Through experiments, students practice thinking scientifically and find evidence of the truth of the theory they are studying. Experiments can maximize the learning of abstract concepts and scientific theories, because they allow students to engage in real practical work rather than sitting in class and absorbing material about concepts and theories (Ibrahim et al., 2014). In this study, the identification of the implementation of the experimental method in schools was carried out. The study was conducted at various schools in eastern, central, and western parts of Indonesia, consisted of 26 teachers.

The results showed that as many as 80.8% of participants stated that their school had carried out experiments and most stated, that in one semester, they carried out experimental activities more than twice, even 38.5% of participants carried out these experimental activities more than three times. However, when comparing whether the teachers carried out experimental activities or just experimental activities that were cookbooks, it turned out that most of them had not carried out experimental activities. A total of 76.9% of participants stated that the work procedures in laboratory activities were provided by the teacher and only 19.2% asked their students to design their own experimental steps. This is not in accordance with the basic concept of experimental activities, namely discovery. The experimental method is a learning method that facilitates several students to work in groups on carefully designed guided inquiry questions (SERC, 2018).

In experimental activities, the teacher's role is to be a facilitator, not as a commander or leader of experimental activities. The teacher is tasked to stimulating students to carry out laboratory activities independently, by providing tools for students to collect data through interaction with typical laboratory materials, data simulation tools or decision-making environments, as well as a series of questions that lead to discovery-based learning. Based on the research results, experimental activities have not been implemented optimally. The teacher still dominates in preparing the tools and materials needed during the experiment. As many as 57.7% of teachers stated that the tools to be used for laboratory activities had been provided by the teacher, so that students' skills to choose appropriate laboratory equipment had not been developed. However, the positive side is that as many as 50% of participants stated that their students were asked to bring some and/or all the required experimental materials.

There are three main obstacles that engender teachers not being able to design optimal experimental activities like facilities and infrastructure, student character, and time allocation. The constraints on facilities and infrastructure, mostly caused by the tools needed in laboratory activities are incomplete and materials are not available, and the place is not representative for experimental activities. These results are in accordance with the research of Sari, et.al (2020) which caused teachers have adversity to carried out of experiment. Data constraints on facilities and infrastructure are shown in Figure 1.

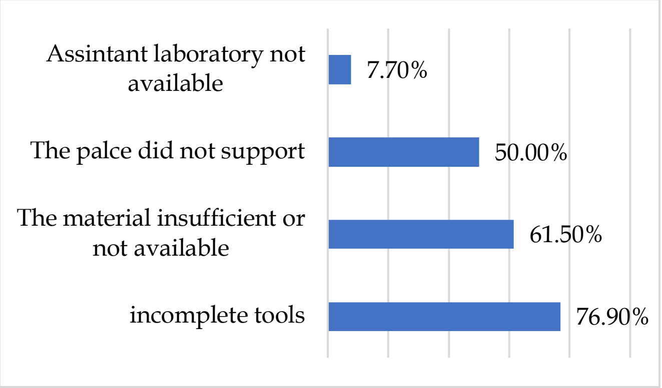

Figure 1. Constraints on facilities and infrastructure

The success of experimental activities cannot be separated from the attitude or character of students. The positive character of students will support experimental activities to run smoothly, the objectives and learning scenarios that have been previously designed by the teacher can be carried out. There are two main obstacles related to the character of students in laboratory activities, namely experience and learning independence. First, the learning experience in doing is still quite low so that when students are asked to design their own experiments, they will also experience difficulties. Second, students' independence is still low, namely students are still lacking in the desire to learn and prepare themselves when going to do experiments. Constraints related to the complete character of students are shown in Figure 2.

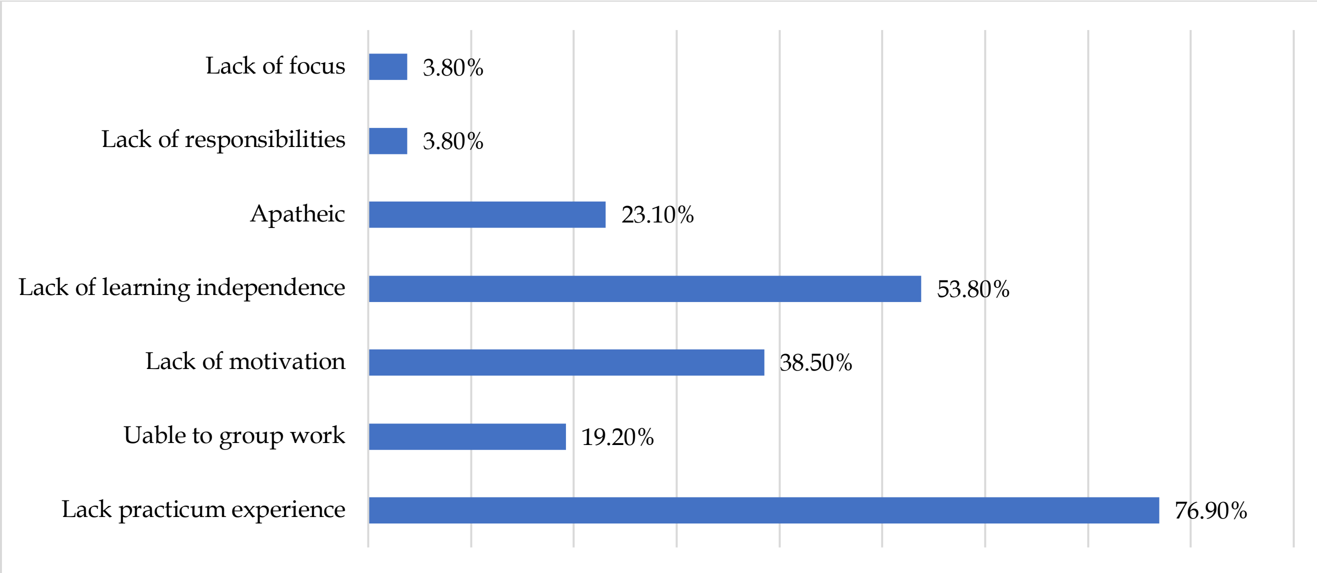

Figure 2. Experimental constraints related to student character

The third obstacle that was faced by teachers when conducting experimental activities at school was the time constraint. Most of the teachers stated that the time to carry out the practicum was less. This can be caused by the burden of material required to be completed by the teacher and the practicum does not have its own schedule. The constraints related to time for experimental activities are shown in Figure 3.

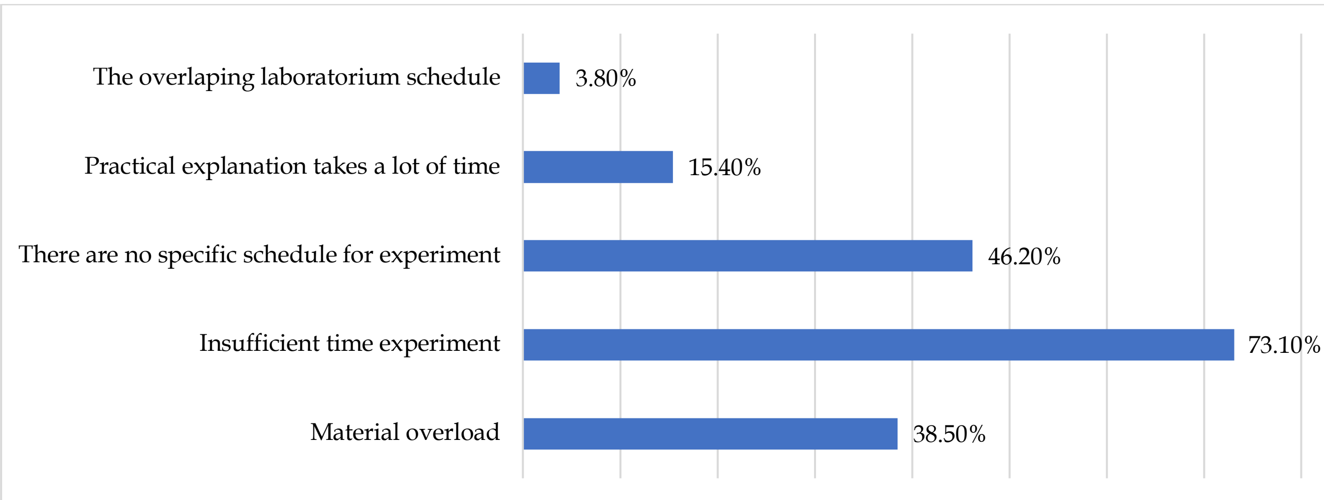

Figure 3. Experimental constraints related to time

The research shows that there are various efforts used by the teacher in solving the obstacles faced in the implementation of the experiment. An effort to anticipate obstacles related to facilities is to use substitute materials that are easily found around the student's environment, such as plant extracts. In addition, teachers also develop their own simple experimental tools. Most of the teachers (73.1%) used group learning strategies to anticipate obstacles related to student character. The teacher also uses a variety of learning models and prepares student activity sheets to increase student participation. As for the time constraint, 42.3% of teachers gave demonstration videos and 38.5% of teachers gave explanations of experimental material outside of classroom learning activities so that when in the laboratory the teacher did not need to explain again. The explanation of experimental material through online learning platforms was only carried out by 11.5% of teachers.

Based on the responses given by the teacher regarding the implementation of the experiment. This activity has not been optimally implemented, especially regarding on the process of preparing the experimental procedure design by students. The teacher's point of view was that students had not been able to design it properly. Most (73.1%) teachers stated that their students belonged to the category of passive students, so it was difficult to carry out experimental activities properly. The teachers were also thinking that when students were asked to design their own procedures, it will take a long time, students will also have difficulty implementing the experimental steps carried out and are prone to wrong goals.

In fact, the problems that can arise in line with the application of the experimental method can be overcome by guiding students in stages. These stages are providing sufficient explanation of what must be done in the experiment, talking with students about the steps taken by the required learning materials, variables that need to be observed and things to note, determining the main steps in helping students during the experiment, determining (follow-up) experiments (Nugroho & Margiati, 2019). Experimental stages can be streamlined by using pre-lab activities.

Research shows that almost all teachers (96.2%) stated that pre-lab activities are important to do. The teacher stated that the pre-lab can provide an overview of the experiments that will be carried out so that students become more prepared, increase the efficiency of practicum time and anticipate mistakes in following experimental procedures. The majority of teachers (61.5%) used the lecture method for pre-lab activities. Other pre-labs that the teacher uses are demonstrations, using videos, quizzes, and pretests. Data on the pre-lab method or technique, used by the teacher, are shown in Figure 4.

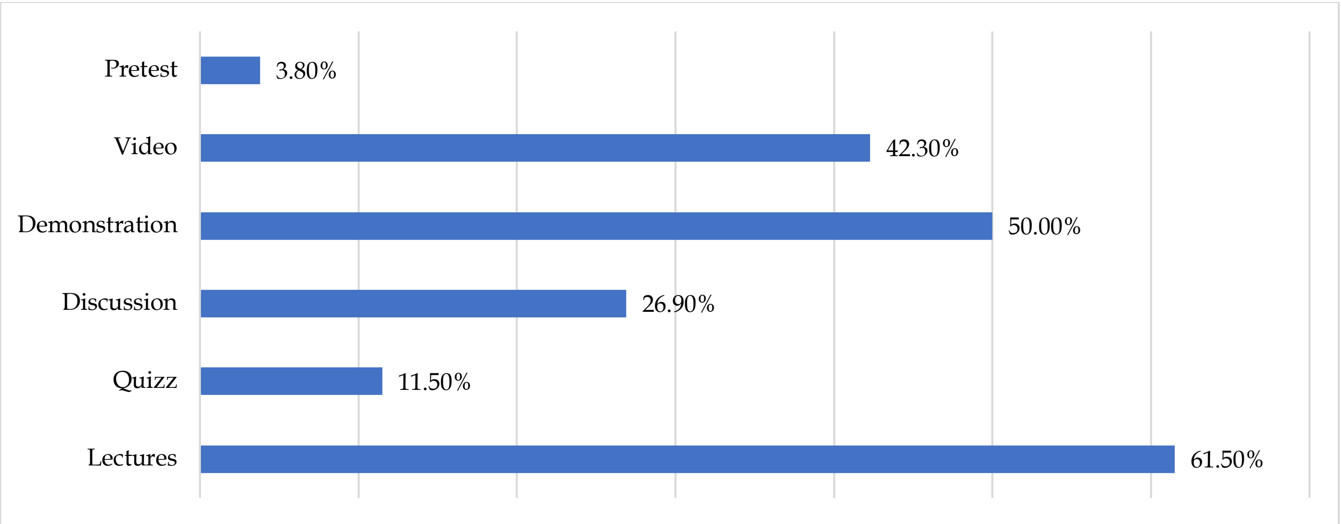

Figure 4. Pre-lab technique

On further exploration of the teacher's opinion about possibility that pre-lab would be developed using virtual learning (VL), almost all teachers (96.2%) agreed. The consideration for developing a pre-lab with VL is the efficiency of time and space provided by VL. In VL, teachers and students do not have to meet face-to-face and allow students to learn independently, so they do not require a special time allocation for learning in class. In VL learning, experiences are enhanced through the use of computers and/or the internet both outside and inside educational organization facilities (Racheva, 2017). VL is an online environment where various tools are provided to teachers and students to facilitate the learning experience. Teaching activities are carried out online when teachers and students are physically separated (in terms of place, time, or both). The use of online technology to support experimental activities can increase student readiness. This is because they can obtain information flexibly and become more familiar with the procedures and theories of the topic to be experimented with (Gregory & Di Trapani, 2012). The media which was most chosen by teachers when it will be developed virtually is video (88.5%). Other media that can be considered is in the form of an android application which is chosen by 50% of participants. Virtual media is intended to perform real chemistry laboratory (Mutlu & Şeşen, 2016) and enhance the student's science process skills (Gunawan, G., Sahidu, H., Harjono, A., & Suranti, 2017).

Conclusion

Based on the results of data analysis shows that experimental activities have not been fully applied to science learning. Most teachers provide the tools and materials needed in learning activities in the laboratory and provide work procedures to students. Constraints that were faced by teachers in applying the experimental method were related to facilities and infrastructure, student character, and practicum time allocation. Most of the teachers have also carried out pre-lab activities, but they were still dominated by lectures from the teacher. This study also explored the pre-lab model to be developed, almost all teachers agreed if the pre-lab was developed in the form of virtual learning. The forms of media that are in great demand by teachers for pre-lab activities are videos and android applications.

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