A PORTABLE LABORATORY WITH INTEGRATED LOCAL WISDOM FOR PHYSICS EDUCATION BASED ON LECTURER AND STUDENT PERCEPTIONS

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ABSTRACT

Learning a laboratory-based subject, such as physics, requires the student to be present in a laboratory for an optimum learning outcomes attainment. However, building laboratories with equipment are expensive where some institutions in certain countries could not afford it. This study aims to obtain data and perform analysis of the needs to develop portable physics laboratory based on information technology with embedded systems and the integration of local wisdom values in the contents. Samples involved in answering the questionnaire are from students and physics lecturers across the universities in Indonesia. The results of this research discuss perception from lecturers and students in 3 aspects about laboratory and learning physics, physics laboratory based on information technology and portable laboratory with integrated local wisdom (PL-ILW). Finding shows that 93.6% of the lecturers and 84.8% of the students are strongly agree and mostly agree for the development and implementation of a PL-ILW. The result shows that PL-ILW is suitable not only without the existence of a conventional laboratory, but it also suitable as add-ons where the portability is an advantage to be used at different locations.

Keywords: Physics education, embedded system, portable laboratory, local wisdom

1.0 INTRODUCTION

1.1 Overview

In the industrial era 4.0, technological advancements are used to facilitate an ever-evolving learning process. At present, an educator has the opportunity to show in front of the class, the evolution of equations and systems of physics by varying parameters in real-time, through commercial software such as Wolfram Mathematica, Matlab, and Labview. In other cases, simulations can be made with a variety of different computer languages. In addition, data acquisition tools can be used to create experimental data automation [1]. These offer a new alternative to teaching physics, with a blend of technology in learning specifically physics, of course, which will further improve the quality of learning [2].

Until now, various research on information technology-based physics laboratories continues to be developed. For example, combining of modern data acquisition tools and data fitting with modeling tools for conducting physics experiments in secondary schools [3]. Then, develop a simple Arduino-based experiment to find the coefficient of kinetic friction in the inclined plane using a moving object. With this experiment, data collection can be done in a short time and at low cost [4]. And also, an approach of the laboratory on practicum physics using information technology with the automation of the laboratory using a program instrumental complex (e-lab) based on web-technologies [5].

From various laboratories information technology-based, reported that kinds of technologies in physics laboratories are microcomputer-based laboratories (MBL), simulation or virtual reality, remote laboratories, and augmented reality (AR) [6]. Based on the framework for technology-enhanced laboratories, it shows that MBL is a great potential to develop [7]. One of the advantages of MBL is a real-time display of experimental results, thus facilitating a direct connection between the real experiment and the abstract representation [8]. With use of MBL, student spends more time for analysis of experiment results and to form scientific knowledge [9], so MBL are applied at the university [4][10], high school [3][11] and other levels.

MBL is not perfect, so MBL needs modification to the optimization of learning objective, technology, and local condition [12]. To answer the challenges of industrial revolution 4.0, technology in education must fit the classroom context and curriculum. It is reinforced by Tinker [13] that MBL must be embedded in a curriculum of the school and social context. Modification of MBL such as I-Virtual MBL [10] and Mobile Computer-based Physics Laboratory (MCPL) which is a combination of the use of mobile science laboratory (MSL) and MBL [14] and portable laboratory [15].

1.2 Portable Laboratory

Portable laboratory and MBL have many similarities, but it is not the same. Portable laboratory focusing on mobility or portability where it can be brought and used anywhere for teaching and learning [15]. While MBL is almost similar, but it might not be mobile and easy to bring anywhere else. Similarity portable laboratory and MBL usually in hardware like single-board computers and sensors. One of the advantages of portable laboratories from MBL are the low cost, so it is suitable for developing countries.

Portable lab or portable laboratory is equipment/kits to demonstrate and teaching in the class where the student can have immediate feedback by applying the knowledge and theories they learned during and before the class session [16]. Portable laboratory has some characteristics like relatively small in dimension and adaptable for being used in various places and classrooms [15]. Reck et al [17] implies that a portable laboratory is lab kits that allow students to take home laboratory equipment to complete experiments on their own time. So that, we can define a portable lab is lab kits/equipment to demonstrating and teaching in various places and classrooms.

1.3 Local wisdom

The successfulness of the physics learning process can be obtained when the daily life of learners are integrated into the learning process, especially the local wisdom of a region [18]. Local wisdom is the values of knowledge and useful values on society that have been validly tested [19] [20]. The concept of local wisdom also known as concept of cultural heritage [21], in countries other than Southeast Asia better known as cultural heritage. According to Jagielska-Burduk [22] cultural heritage is a non-renewable resource with an intrinsic value, which is certainly in line with the notion of local wisdom. Many researchers have bringing cultural heritage in a classroom and integration with technology [23][24][25].Indonesia rich with local wisdom, especially in Java there is a variety of local wisdom namely the Othok-Othok Ship, Jemparingan, Andong, Rebab, Siter and Waterwheel [26]. Local wisdom and concept of physics be reviewed and then integrated into contextual learning. Studies [19][27] about the integration of local wisdom in teaching and learning showed that students' abilities can improve.

Based on these problems, portable laboratory with integrated local wisdom (PL-ILW) can be an alternative solution in teaching and learning physics. Therefore, a preliminary study on the development model of a portable laboratory with integrated local wisdom (PL-ILW) is presented in this work. The result of this preliminary study is lecturer and student perception to develop portable laboratory with integrated local wisdom (PL-ILW) for Physics Education.

2.0 RELATED WORK

Local wisdom can be integrated into contextual learning media, especially for Indonesia as a country rich in local wisdom so that students get better knowledge about the richness of Indonesian culture and can be used to support learning [26][27]. Integrating local wisdom in science learning can use 4 models, namely: adaptation model, addition model, correction model, and neglected model [28]. Integrating local wisdom in the application as learning media can be a game [29][30], comics [31], electronic book [32], and Multimedia learning modules [33]. The integration of local wisdom in education is not only emerging in Indonesia but also emergent in other countries, such as Thailand [34][35][36]. Local wisdom is seen to be able to provide a good contribution in improving student learning outcomes because it is contextual by the environment around students [37][38]. In line with this, the use of ICT in learning also has a good impact [39][40].

The integration of local wisdom in physics educational applications can meet the learning outcomes[29][30][31] [32][33], although each application cannot provide learning outcomes for the 4 criteria. Most of the learning outcomes on critical thinking and problem solving refer to 21st-century skills [33][41][42].Critical thinking and problem-solving are 2 of the 7 core skills needed to face the 21st century [43]. Also, the integration of local wisdom in physics educational applications also has an impact on the aspects of cognitive outcomes [19] [32] [44], skill-based outcomes [19], and affective outcomes[44].

Table 1 shows the list of Indonesian local wisdom and the equivalent physics concept for integration. The local wisdom as Nekeran [32] and Othok-othok ship [41] can be integrated into the same material as Newton's Law. Also, Belogo and Traditional Rowing Contest [33] and Hopscotch (reklek) [31] are integrated into Impulse and momentum materials with different types of applications, namely Multimedia Learning Modules and Android-Based Applications. Based on this, it can be concluded that the integration of local wisdom can be carried out in various materials, besides that one material can be integrated with various local wisdom in the physics educational applications.

Table 1: Indonesian local wisdom and the corresponding physics concept

Indonesian Local Wisdom	Physics Concept
Sulamanda (Engklek) [31]	Impulse and Momentum
Waterwheel [19]	Circular motion, Potential Energy, Kinetic Energy
Indonesian Batik Culture [44]	Heat
Bamboo Cannon [28]	Sound Wave
Nekeran [32]	Newton’s Law
Othok-Othok Ship[41]	Newton’s Law
Belogo and Traditional Rowing Contest [33]	Impulse and Momentum

Indonesia and Thailand have been doing a lot of research and development on the integration of local wisdom in education. Pornpimon [36] has developed a strategy for integrating local wisdom in primary schools in Thailand. The integration of this local wisdom will provide a picture of the real world and the surrounding environment [45]. Every country must have a unique culture so that it tends to use theory following the conditions of its surrounding environment which are of course different from one another [46]. Suastra [38] states that local wisdom can accommodate the need for illustration in learning because of its relevance in daily life.

3.0 MATERIALS AND METHOD

3.1 Aims

The main aims of this study to design a portable laboratory with integrated local wisdom (PL-ILW) based on sentiments. This preliminary study was carried out by analyzing theories and doing field-observation to obtain data of needs of portable laboratory with integrated local wisdom (PL-ILW). This study uses qualitative descriptive analysis methods.

3.2 Participants

The participants of this study consisted of physics lecturers and students taking physics courses. There are 20 lecturers from 17 universities with 8 different departments. Lecturer participants come from 9 provinces in Indonesia with 80% male and 20% female. Student participants totaled 221 from 2 departments in Duta Bangsa University, Surakarta, Indonesia with 84.6% male and 15.4% female. Table 2 shows the classification of participants.

Table 2: The clasification of participants

Classification of participants	Degree	Number of participants
Lecturer	Doctorate	4
	Master	16
Student	Undergraduate	221
Total		**241**

3.3 Instruments

There are two instruments in this study, namely a questionnaire for lecturers and students. The first step in the development of the "questionnaire for lecturers" and "questionnaire for students" was a literature search. The questions in the questionnaire were made with the information obtained from the literature search. To ensure the validity of each question item, a validity test was performed with the Pearson correlation. Question items which were invalid based on the validity test were removed from the questionnaire and the others were changed. After that, re-tested the validity of the questionnaire. Value of Pearson correlation for the questionnaire for lecturers with 11 questions ranged 0.539 to 0.847 and value of r table 0.444 at sig level 0.05. Value of Pearson correlation for the questionnaire for student with 10 questions ranged 0.572 to 0.823 and value of r table 0.304 at sig level 0.05. The Reliability of the questionnaire instrument was done using Cronbach Alpha (α). Table 3 shows the value of the α for the instrument. The results of the validity and reliability test show that the question items are valid and reliable. The result of the above process the questionnaire is finalized. The five-point Likert type was used in two questionnaire instruments with the following grades: 1 for strongly disagree, 2 for disagree, 3 for neutral, 4 for agree and 5 for strongly agree.

Table 3: The need analysis instrument for develop PL-ILW

Aspect	Lecture	Student
Need analysis Instrument for Develop PL-ILW	0.894	0.906

4.0 RESULT AND DISCUSSION

The two questionnaires were conducted to 20 physics lecturer and 221 students. Before answering the questionnaire, the lecturer fills in the data on the availability of a physics laboratory at his university, the results are shown in Figure 1. From these data it is known that the availability of a physics laboratory at the university is 88%. The availability of physics laboratory became underlying ground to develop information technology-based laboratory. The results of this research will discuss opinions from lecturer and student in 3 aspects about laboratory and learning physics, Physics laboratory based on information technology and PL-ILW.

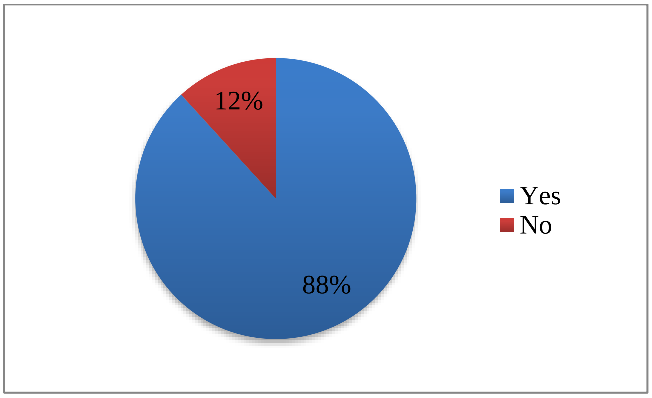

Fig. 1: Availability of physical laboratories at universities in Indonesia

4.1 Laboratory and Learning Physics

The result of lecturer perception about laboratory and learning physics is shown in Figure 2. The results of lecturers' perceptions related to the question "The experimental / practicum method is needed in learning physics" showed that 85% strongly agree and 15% agree. This is confirmed by the lecturers' perceptions regarding the question "The Use the experimental / practicum method in learning physics" shows 80% strongly agree and 20% agree.

The result of student perception about laboratory and learning physics is depicted in Figure 3. The results of students' perceptions regarding the need for a laboratory in learning with the question "Laboratory is needed in learning physics" showed that 95% strongly agree and agree. Then the students' perceptions of practicum implementation with the question "Do you agree learning physics using experiment / practicum?" indicating that 85.5% strongly agree and agree. This is reinforced by student perceptions of the impact of laboratory use on learning outcomes, with the question "The use of laboratories increases understanding of physics concepts" showing 91.9% strongly agree and agree.

Lecturers' and students' perceptions regarding the laboratory and learning physics corresponding to the theory that use of laboratories in physics learning is widely recommended because it is seen as a fundamental tool for understanding physical phenomena and underlying theoretical concepts [47]. The availability of adequate laboratories and optimal utilization is very influential on the quality of physics learning output [48]. The impact is that have laboratory availability and are optimally utilized in learning produce good learning outcomes [49]

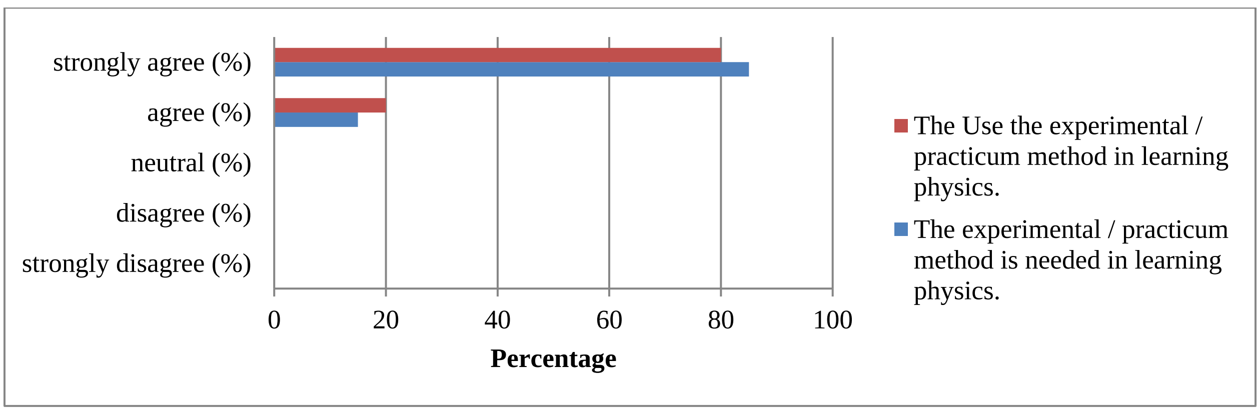

Fig. 2: Lecturer perception about laboratory and learning physics

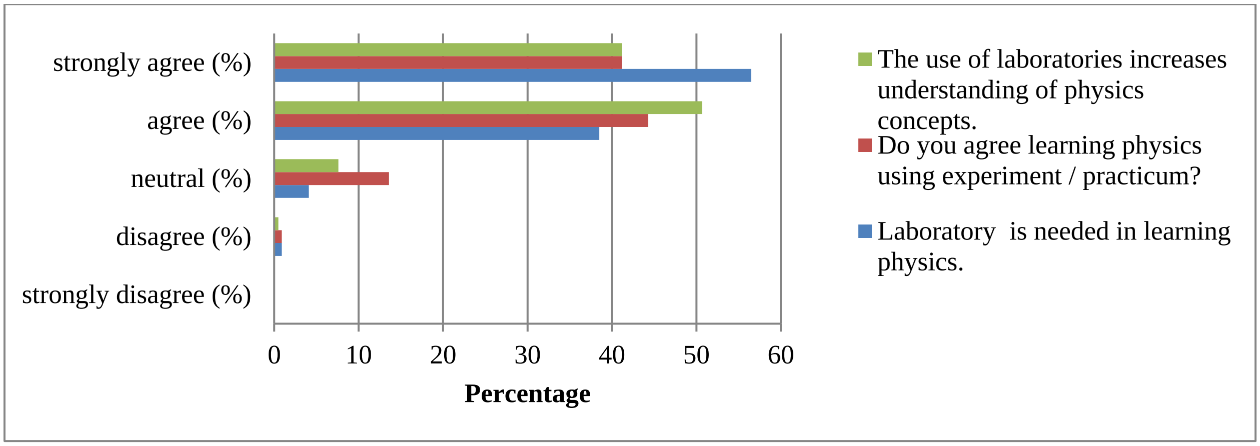

Fig. 3: Student perception about laboratory and learning physics

4.2 Physics Laboratory Based on Information Technology

The result of lecturer perception about physics laboratory based on information technology is shown in Figure 4. The results of lecturer perceptions regarding question "The use of information technology in learning can improve student understanding" showed that 100% strongly agree and agree. Then, lecturer perceptions regarding question "Physics laboratory based on information technology can improve student understanding" indicating that 90% strongly agree and agree. This is reinforced by lecturer perceptions regarding question "Physics laboratory based on information technology can improve student skills and techniques (data analysis, report writing, etc.)" showed that 75% strongly agree and agree. In addition, the perception of lecturers with the question "Physics laboratory based on information technology cheaper and efficient" shows that 85% strongly agree and agree. The lecturer also stated that 95% strongly agree and agree in developing a physics laboratory based on information technology, to support physics learning using experimental / practicum methods.

The results of the lecturers' perceptions are also in line with the results of the student questionnaire shown in Figure 5. Student opinions stated that 85.1% strongly agree and agree that the use of information technology in learning can improve understanding. The student opinion also stated that 86.4% strongly agreed and agreed that the information technology-based physics laboratory was interesting. Students also stated that 86.9% strongly agreed and agreed to develop an information technology-based physics laboratory to support physics learning using experimental / practicum methods.

The two broad functions that technology can provide in laboratory learning are exploration and investigation [7]. Laboratories with advanced technology offer students the opportunity to explore phenomena or objects and support student investigations in laboratory work. Regarding the physics laboratory based on information technology lecturers' and student perceptions corresponding to the theory that technology offers powerful tools that support teaching, learning, and education in general [50].

In addition, technology-based laboratories can reduce the time required for investigation [7]. The theory is in accordance with the lecturers' opinion that 85% stated strongly agree and agree regarding physics laboratory based on information technology efficient. Furthermore, time constraints are the main reason why technology should be used to replace traditional laboratories [51]. This theory is in accordance with the opinion of the lecturer who stated that 95% strongly agree and agree to develop an information technology-based laboratory. This opinion was corroborated by students who stated that 86.9% strongly agree and agree.

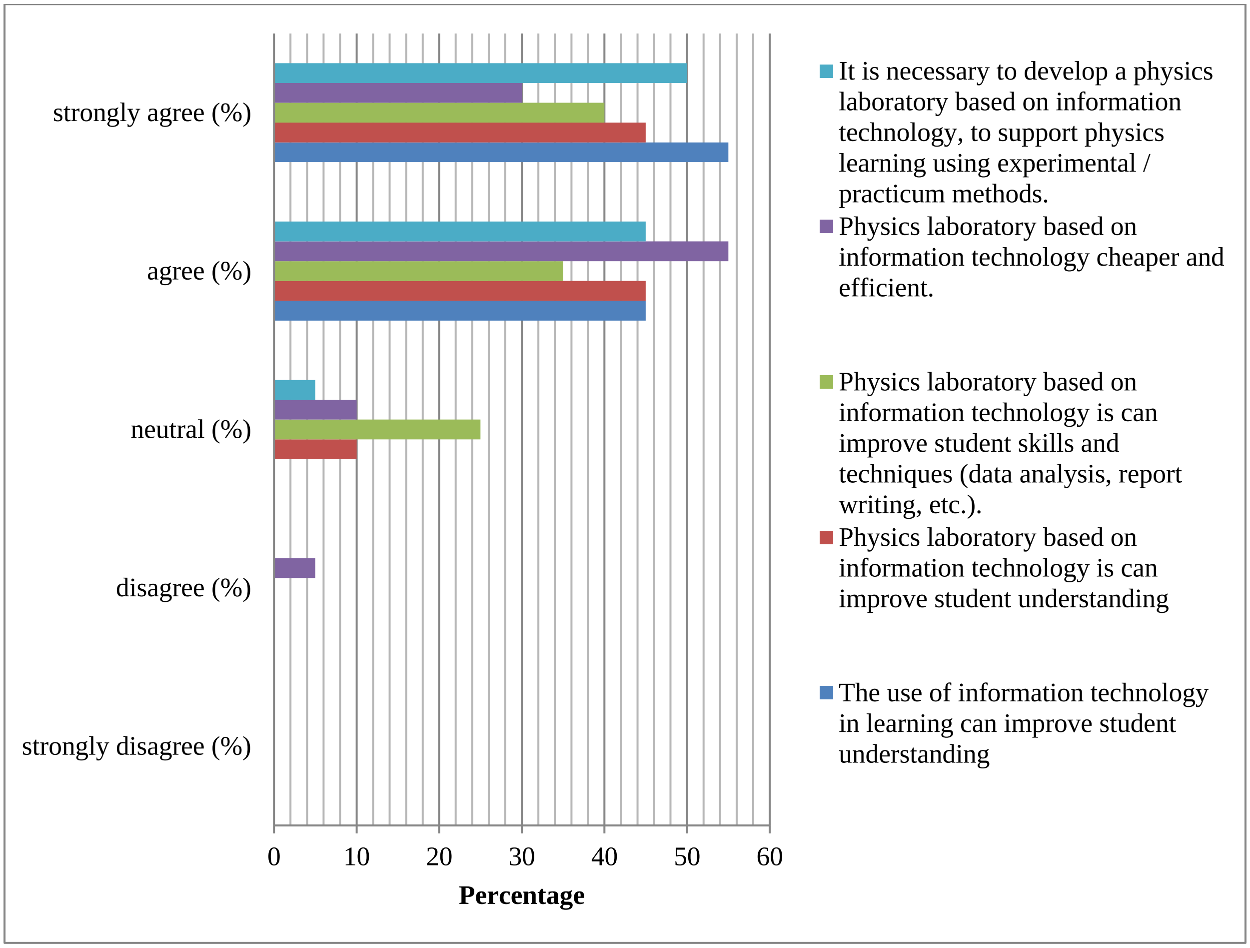

Fig. 4: Lecturer perception about physics laboratory based on information technology

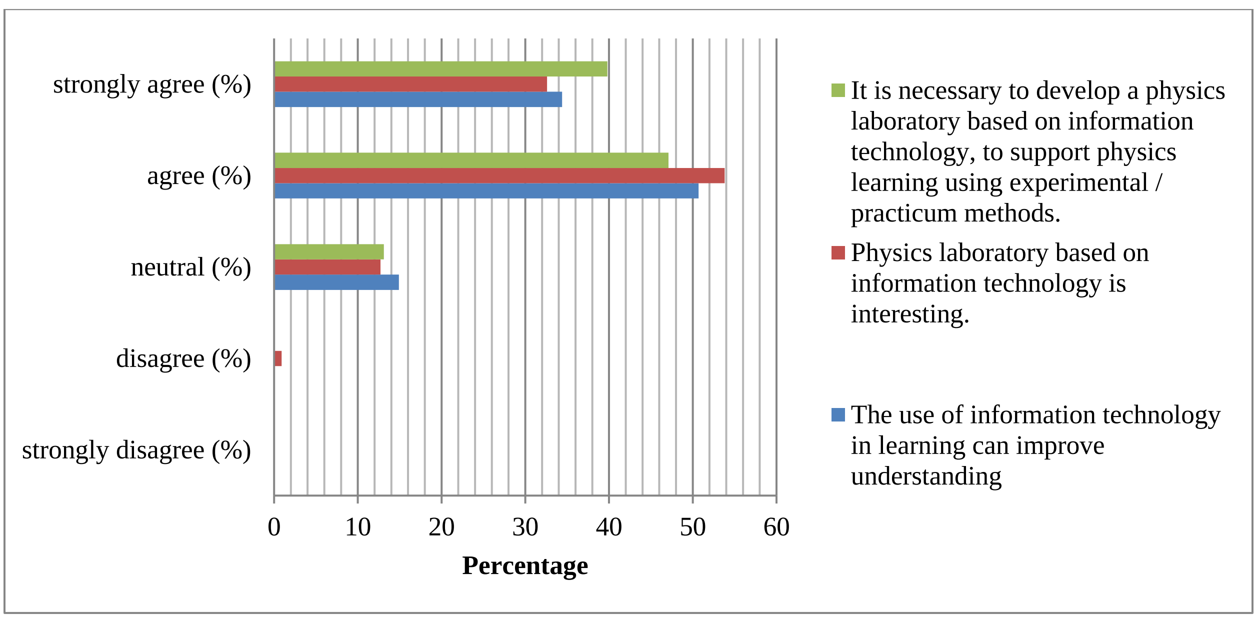

Fig. 5: Student perception about physics laboratory based on information technology

4.3 Developing PL-ILW

The use of technology for laboratory development has grown rapidly in developed countries, but has not developed extensively in developing countries such as Indonesia [6]. Indonesia faces special challenges due to poor network system and shortage of ICT equipment [52]. For this reason, the development of technology-based laboratories must be developed in accordance with existing characteristics in Indonesia.

The result of lecturers and students' perception about development of Pl-ILW is shown in Figure 6 and Figure 7. The lecturer perception is 100% strongly agrees and agrees that physics laboratory based on information technology developed based on MBL. The results of student opinions also stated the same thing that 74.6% strongly agreed and agreed. This result is in line with the theory that technology laboratories for physics labs are in the form of microcomputer-based laboratories (MBL), simulations or virtual reality, remote laboratories, and augmented reality (AR) [7]. Microcomputer-based laboratories (MBL) have a greater potential to be developed compared to other types. One of the main advantages of using MBL is the real-time display of experimental results and graphs thus facilitating a direct connection between the real experiment and the abstract representation [8].

The result of lecturer perception is 100% agree and strongly agree, and also student perception is 76.5% agree and strongly agree about the Microcomputer-based laboratories (MBL) need to be developed into a portable laboratory as a physics laboratory that can be used in class or outside the classroom. The result in line with [12] that MBL needs modification to the optimization of learning objective, technology, and local condition. Portable laboratory has some characteristics like relatively small in dimension, adaptable for being used in various places and classrooms and allow students to take home laboratory equipment to complete experiments on their own time [15][16][17]. Based on the characteristics of Portable laboratory can be effective to full filled the gap of MBL.

The average of lecture perception is 92.5% agree and strongly agree, and also student perception is 83% agree and strongly agree about integration local wisdom in portable laboratory. The result in line with [27][19] that integration of local wisdom in teaching and learning can improve students' abilities.

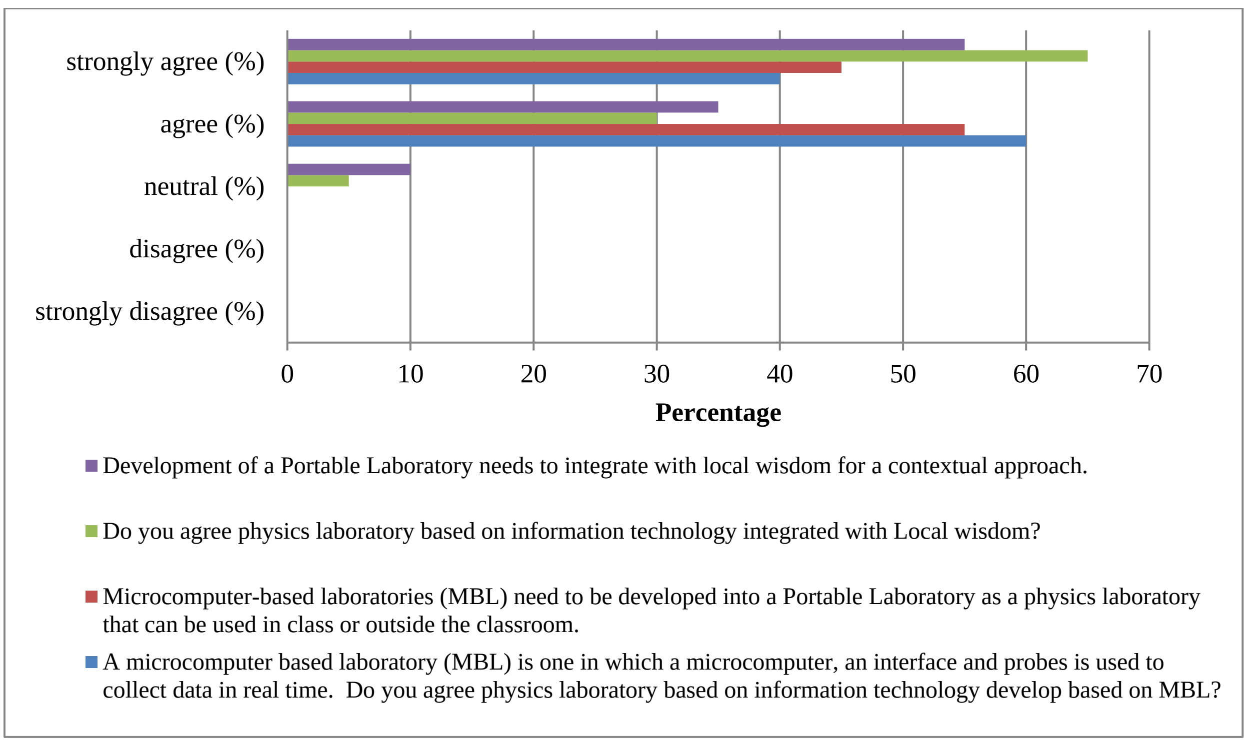

Fig. 6: Lecturer perception about developing PL-ILW

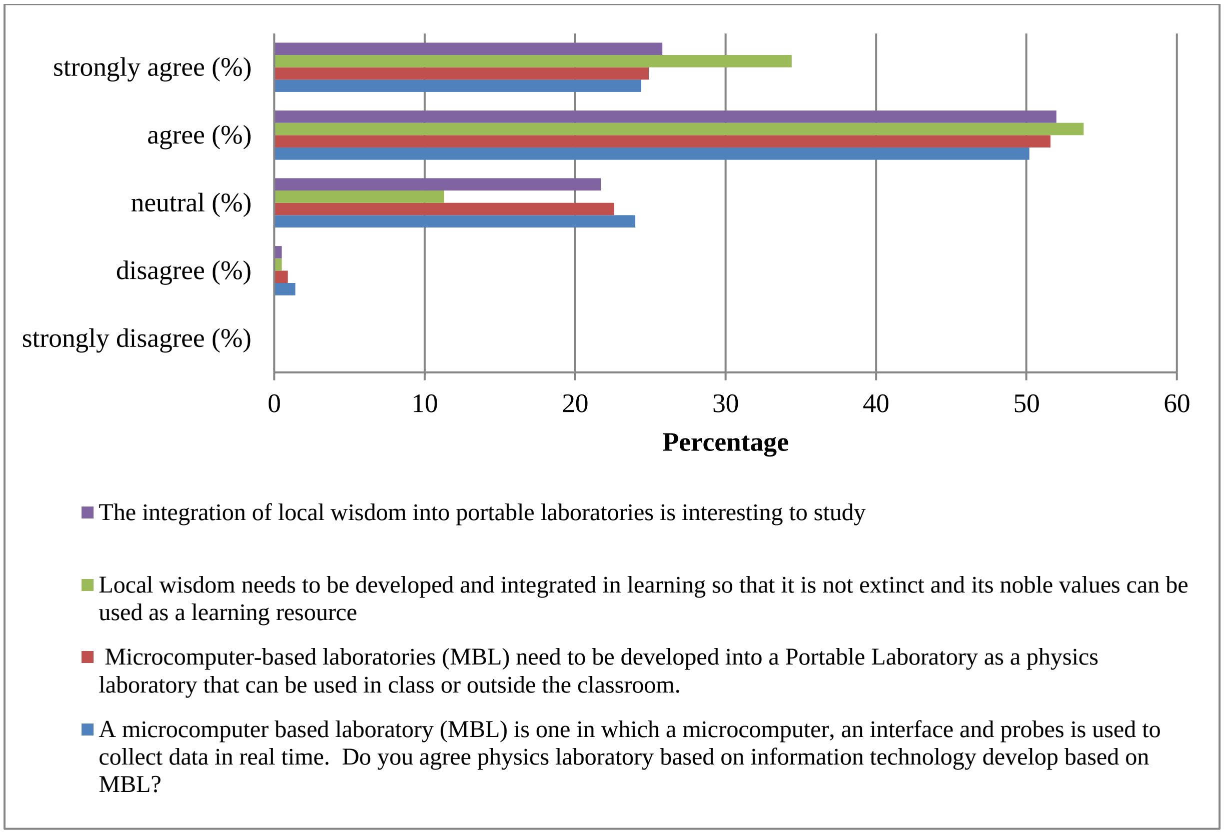

Fig. 7: Student perception about developing PL-ILW

5.0 CONCLUSION

Findings of this study are perceptions from lecturers and students for the development of information technology-based laboratory. Findings also show that information technology-based portable laboratory with integrated local wisdom (PL-ILW) is suitable to be developed as physics laboratory in Indonesia. The result show that 93.63% of the lecturers and 84.79% of the students agree and strongly agree for the development of PL-ILW. This result is an essential preliminary finding for this study to move forward to the further stages. Thus, it is hoped that this PL-ILW can improve students' abilities to improve learning outcomes.

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