

# Tpack as Innovation of Learning Science Laboratory of Indonesia

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**Abstract**—21st century education produces culture for the principals of teachers, students and the environment to integrate technology, pedagogy, and content mastery (TPACK) into a single entity. One way to achieve learning goals that are in line with 21st century learning that is also a form of industrial revolution 4.0 is laboratory-based learning and integration of IT use in science learning. The purpose of this research is to find out the best formulation in the use of technology that can be considered in laboratory-based learning. Many options to implement the application of technology in laboratory-based learning including virtual lab, remote lab and MBL. This study used the Systematic Literature Review (SLR) method. It is used in this article will illustrate the advantages and disadvantages of each type of technology commonly used in science-based laboratory learning in the world. Therefore, the role of teacher / educator is important to design and select the right technology in building learners' knowledge. Based on the results of each analysis Technology (virtual lab, remote lab and MBL) is not perfect, it needs modification in order that the learning objectives, the use of technology and the local conditions can work optimally. Educators need to emphasize that what is more important is that learning activities are not located within the mastery of computer technology but in their educational practices.

**Keywords**—laboratory, science, TPACK.

## I. INTRODUCTION

The shift in the educational paradigm from instructive philosophy to constructivist led to a shift in the need for education. This can be seen from the current education known as 21st-century education. Currently, the science teachers are encouraged to use advanced technology in accordance with a meaningful pedagogical framework in learning materials [1] whose ultimate goal is to support students in studying science [2].

The twenty-first century education has transformed the skill of knowledge from the acquisition of structured knowledge into the mastery of skills. There are four attributes for teaching and learning in the twenty-first century demanding [1], students are able to adapt to change and uncertain situations. The next attribute is collaboration and communication in a decentralized environment. The third attribute is data generated and information management, and the last attribute is the release of controls by encouraging exploration. The implication of this is that educators need to know the foundation in utilizing computer technology to be used in teaching. Further Educators need to emphasize that more important is the learning activities are not located in the mastery of computer technology but in the

practice of education. Educational practices developed with integration or with the use of computer technology used by educators must fit the classroom context and curriculum, and most importantly how students learn science with computer technology rather than simply focusing on the use of computer mastery techniques [2]. These four attributes of 21st century learning can be achieved with a balance of technological, pedagogical, and content knowledge (TPACK).

However, 21st century education is not easy to realize. This is related to the constraints that exist in our education. The first obstacle is the challenge of teaching innovative science [3]. The second barrier is classroom and school connectivity. The third obstacle is the difference in expectations of teachers versus students. The challenge for science educators today is to develop a pedagogical model that can engage students authentically, in the form of an inquiry in which they develop science, the ability to think, not just to make teachers a source of knowledge as described by Lemke [4]. The fourth barrier is a change in classroom management. [3]

The rest of this paper is organized as follow: Section II describes proposed research method. Section III presents the obtained results and following by discussion in section IV. Finally, Section V concludes this work.

## II. PROPOSED METHOD

The TPACK becomes unavoidable in 21st-century learning. This research is a study using literature review. This research uses Systematic literature review (SLR) as shown in Figure 1, has been recognized as one of the scientific activities [5]. Research has conducted a literature review that can systematically capture and integrates existing information and provide direction for effective research. A systematic unified literature review has been used extensively to (a) establish, rationalize, and revise hypotheses, (b) understand and minimize previous employment traps, (c) obtain estimated sample sizes, and (d) identify important confounding effects and covariates that need to be considered in future studies [5]. To provide guidance for systematic integrated literature review, the literature can be analysed in six components of interest: (a) databases are used to retrieve articles, (b) theoretical perspectives or frameworks used to conduct systematic integrated literature reviews, (c) tools (d) integrative tables and their contents; (e) methods used to sort or categorize articles; and (f) methods used to synthesize findings.

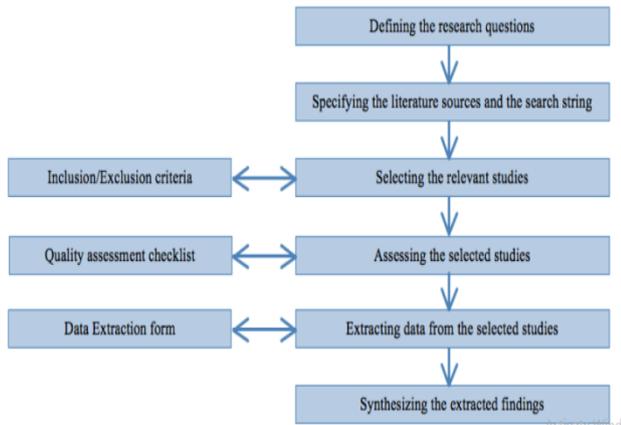


Fig. 1. Systematic Literature Review Scheme

**III.RESULTS**

*A. TPACK in Laboratory-based learning*

Mishra and Koehler [6] and Koehler and Mishra [7] developed a Technological Pedagogical Content Knowledge framework that we can follow in order for teachers to know more about the combination of those components that can be used and integrated in the learning process. In addition, the objective of science and technology is to enable students to (a) use scientific processes in problem solving, decision making, (b) understanding the nature of science and technology, (c) critically analysing recent scientific knowledge and its role in society human [8]. Therefore, it will be potential and excellence if science learning and the use of technology can be mutually reinforcing. In achieving conceptual understanding, the material of physics is not enough only with classical activity but also the need to practice and recognition with real phenomena. Therefore, physics learning is closely related to laboratory and practicum. One of the goals of the laboratory-based learning of physics and science is to teach research and observation approaches, develop problem-solving skills, and help students develop positive attitudes [9]. The laboratory has a very important role in Physics learning. Laboratory activities, students can be trained and equipped with some skills such as observing, classifying, measuring, communicating, interpreting data, and making conclusions. Laboratory activity makes physics learning more interesting and fun. Most educators agree that laboratory activity is an important component of science learning. Experience in the laboratory has a relationship with the development of metacognitive skills [10].

*B. Obstacles in Implementation of IT usage in the laboratory*

According to Siorenta and Jimoyiannis [11], there are three groups of teachers regarding innovation and views on the use of technology in learning. The first group is a group of traditional teachers, whose beliefs are dominated by strict physics content presentations while they do not want to include laboratories and ICTs in their classroom-based activities. The second group consists of non-traditional teachers, who are positive about the application of

laboratory-based and ICT-based teaching materials; and the third group of unconverted teachers who combine elements of the trust structure and the delusion between traditional and non-traditional approaches. But along with the development of existing technology, the use of technology can change the face of the use of laboratories, traditional groups and groups that have not decided will support the use of ICT in learning began to adapt to the demands of ICT use in learning. Along with the use of IT in learning in the laboratory there are some problems and obstacles in the implementation of IT usage in the laboratory can be implemented as shown in Table I.

*C. Pedagogy in the Use of IT in the Laboratory*

The 21st-century education not only requires students to be able to use technology, but more importantly is the mastery of the material. Therefore, on the basis of literature analysis, there are some weaknesses in the use of technology in the laboratory. As each technique in Table II. There is a description of the use of technology in the laboratory has advantages related to pedagogical potential, on the other hand, technological use techniques in the laboratory also have obstacles in the implementation.

TABLE I. OBSTACLES AND IT USAGE SOLUTIONS 21ST-CENTURY EDUCATION WORLD

No	Obstacles	IT Solutions in Science-based Learning Lab
1.	Innovative science teaching	Laboratories with technology can assist students in collecting information and filtering data. It also can reduce the time spent in data collection and graphics, and students will also get precision in the measurement. [12]
2.	Classroom and school connectivity	Use of virtual laboratory enables to be developed environments that can give students the means to access desired experiments without being tied to places and times, and accessible with mobile devices [13].
3.	Differences expectations between teachers and students	Virtual laboratory is a form of interactive virtual learning with an environment tailored to the needs of students and teachers and that embodies all pedagogical, technological and human-specific knowledge to conduct applied experiments [14].
		Master believes that most students have a positive view of the possibility of MBL to study physics in particular because it produces accurate measurements and is assisted in analyzing results while saving time. In addition, the students argue that the MBL supported lessons are good for learning the concepts and principles of physics [15].
4.	changes of classroom management	The use of virtual labs allows flexible, accessible, and cost-effective remote learning and the cost-effectiveness of virtual lab packages will allow learners to acquire practical physics knowledge [16].

**TABLE II. TYPES, ADVANTAGES, OBSTACLES AND IT USAGE SOLUTIONS IN THE LABORATORY**

No	Types	advantages	obstacles	Solutions
1.	Virtual Lab	The use of Computer Simulation in laboratory activities is quite effective for the achievement of student knowledge [17].	The Virtual Lab model can prevent students from recognizing and using real physical tools and devices and interaction between students is limited [18].	The use of EJS as a virtual lab combined with a Moodle-based LMS can produce optimal learning outcomes [19].
2.	Remote Lab	The effects of Remote Laboratory include improving learning conditions, improving students' learning motivation, RL bringing learning activities closer to facing complex situations [20], [21].	The disadvantages of using Remote laboratory include the absence of a teacher who can provide help and slow internet connection that disrupts the remote lab process [22].	The combination of traditional models and the use of technology in Labs in physics learning can improve understanding of physical content [23].
3.	MBL	The use of MBL improves the ability of graphics literacy better than traditional learning, which includes the ability to identify experimental variables, using experimental tools, graphs, formulating mathematical equations, making predictions [24].	Since MBL is a new paradigm, it will take a long time to prepare the tools and classroom management. Includes the need for extra guidance to students .	Compose something more compatible and mobile to make it easier to use it with a combination of gadgets [12].

#### IV.DISCUSSION

The concept of pedagogical and content knowledge (PCK), as the industrial revolution 4.0 turns into Technological, pedagogical and content knowledge (TPACK). The side of the use of this technology is currently being and continues to be developed in the learning activities. Laboratory-based science learning requires selecting the types and strategies that are consistent with the teacher's potential, character and objectives.

There are 3 types of technological use techniques in laboratory-based learning in science lessons: Virtual lab, Remote Lab and MBL. All techniques have advantages and disadvantages, the most important is how to use them in accordance with the existing potential and targets to be achieved by the teacher. Some areas with limited conventional practicum tools may replace them with virtual labs that are currently accessible free of charge through existing online. For schools that want to apply the learning process outside the room with real time data using MBL can be the main attraction. While in schools that want to implement distance learning with more complex lab activities, can bring remote lab with cooperation between school and college.

Laboratory work and activities is an important thing in physics learning. But many challenges in the implementation of learning activities. These challenges can include Innovative science teaching, Classroom and School connectivity, Differences expectations between teachers and students, and changes of classroom management. To overcome these challenges, for Indonesia in particular can use three kinds of technology that is virtual lab, remote lab and MBL. Based on the existing analysis, Virtual lab has the advantage of dissecting many simulations of measuring tools as well as practicable activities that can be freely accessed, with the activity of the simulation-based practicum students' ability to use the real practicum is often the next problem. In addition to the virtual lab there is another form of technology known as the remote lab. Remote lab can be a way for schools to collaborate with colleges, remote labs can be the best way to improve the quality of understanding about existing practicum activities. this is consistent with what has been said by Soares that the current use of remote labs always leads to exciting and rewarding goals, inspires the world of education and can become decisions in the future. [25]. In addition there are also MBL that can generate data in real time with computerized technology that will facilitate the students to take data in practical activities. this is in accordance with the results of a study from Russell et al which stated that MBL can Support the Construction of New Understandings in physics learning in kinematics topic [26]. With these three kinds of technology, the problem of Classroom and School connectivity and Differences expectations between teachers and students and face the demands of 21st century education on Innovative science teaching and changes of classroom management can be minimized.

It is currently being attempted as an answer to the challenges of industrial revolution 4.0. Educators need to emphasize that what is more important is that learning activities are not located within the mastery of computer technology but in their educational practices. Educational practices developed with integration or with the use of computer technology used by educators should fit the classroom context and curriculum, and most importantly how students learn science with computer technology rather than simply focusing on the use of computer mastery techniques.

## V. CONCLUSION

The TPACK in 21st-century learning presents technology as a potential solution in reducing the educational problems that are commonly encountered in educational activities. Technology in learning, especially laboratory-based learning should be tailored to the needs and facilities available in schools. The use of technology is not perfect, it needs modification in order that the learning objectives, the use of technology and the local conditions can work optimally. Educators need to emphasize that what is more important is that learning activities are not located within the mastery of computer technology but in their educational practices. Educational practices developed with integration or with the use of computer technology used by educators should fit the classroom context and curriculum, and most importantly how students learn science with computer technology rather than simply focusing on the use of computer mastery techniques.

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