Studies The Use Of Smartphone Sensor For Physics Learning

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Abstract: The use of cellular technology reshapes the way of teaching and learning. This article reports the use smartphone sensors to perform several experiments designed to teach the fundamentals of Physics. We have adapted traditional physics laboratories with the use of various sensors that can be found on typical smartphones, such as the accelerometer, and light field sensors and magnetic fields and others. This article offers students new ways to think of smartphones as an interesting tool for learning physics for possible applications in experimental and scientific measurements made in the form of demonstrations and not just as a means of socialization. Therefore, with the presence of various smartphone sensors, it can simplify the experiment and make it possible to understand the concepts of physics and what is equally important is reducing costs.

Index Terms: Sensor, smartphone, learning physics, education, learning process

1. INTRODUCTION

The use of mobile devices in all levels of Physics learning has increased significantly in the past decade. Sensors that are found in this new electronic device can be used as an instrument and a new detector laboratory in experimental measurements in Physics [1]. With the penetration of technology and smartphone devices, as well as in all countries have implemented smartphones as one of the tools in the learning system [2]. Regarding physics learning, smartphone tools are not merely intermediaries within students and teachers or available content. Smartphones can also apply in learning physics by supporting students to conduct experiments using smartphone sensors as a measurement device. [3]. As an example, accelerometer, phyphox, acoustic, overtone analyser, audacity, physics toolbox [4][5][6][7]. In addition, with the increasingly sophisticated smartphone technology allows virtually the entire sensor can be compatible in every type of smartphone [8].The use of mobile phones among students is widespread with the development of technology that is very modern. Availability of free applications, making it an attractive tool for conducting experimental and scientific measurements. [9] reported that experiments using smartphone sensors obtained preliminary results and the appropriateness of good between the results obtained experimentally with existing theories. In addition, the use of sensors makes the smartphone in teaching physics in learning technology becomes cheaper, higher performance, and smaller size [10]. On the other hand, another greatness of the smartphone provides the ability to measure simultaneously with various sensors. This is a big advantage because it makes it possible to carry out many experiments, even outdoors and avoid dependence on other instruments and expensive.

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The author assumes that this ability has not been fully exploited, especially using smartphone sensors in learning, especially in physics learning. The author seeks to discuss several types of sensors, applications and devices that involve the use of smartphones in physics learning. This is what makes the writer realize that digital technology offers alternative learning opportunities in different ways; including the relationship between teacher-student, teachers, students and student material. Many studies have found that mobile learning has a positive influence on learning activities [11][12][13]. Flexible mobile devices in learning materials are a key feature of this program. Interactive functions and social communication are believed to be important for involving students and can improve long-term memory. Collaboration between students and communication with the teacher helps students to understand the material and apply knowledge in real cases. Feedback from students also helps in improving teaching skills and makes instruction in learning more innovative [2].

Several articles have been published and discussed smartphone applications in learning. One of them, [14] shows that implementing mobile learning in learning activities in schools can be the latest alternative learning and able to improve the learning outcomes of high school students in Yogyakarta in the subject matter of physics in the high category with a gain score of 0.54. The expression is reinforced by [15] that since 2000, 75% of mobile learning research has focused on life sciences, physics, earth science, space science and chemistry. These studies show that mobile learning contributes positively to student involvement [16], learning achievement [17], attitude [11], and critical thinking skills [18]. In addition, using a smartphone in learning can improve the concepts of learning, collaboration, communication, problem solving and analysis of the knowledge obtained [19].Therefore, the authors are interested in reviewing articles about the use of smartphone sensors for physics learning. The purpose of this review is that the authors want to provide information and perspectives on the types of smartphone sensors both in the form of applications or devices connected to other devices, so that teachers or students find it easier to search, download and experiment. This research offers a comprehensive overview of the application of free applications / sensors that have the potential of higher education in the Physics class.

2 METHOD

We choose articles to be reported in the form of meta-analysis as a method of systematic review. The author starts collecting data through several databases (IEEE Explore, Eric, Proquest, PubMed, Scopus, and Google Scholar), coding each journal, analyzing each journal and writing the main points in various articles, and the last interpretation and concluding. All databases use the smatphone sensor keyword for physics learning. In this article the author limits only discussing the types of applications and smartphone sensors that can be used as a medium of physics learning that can be used by teachers in the learning process. Articles used on each database are limited from 2010-2019. The following flow of review in the study process.

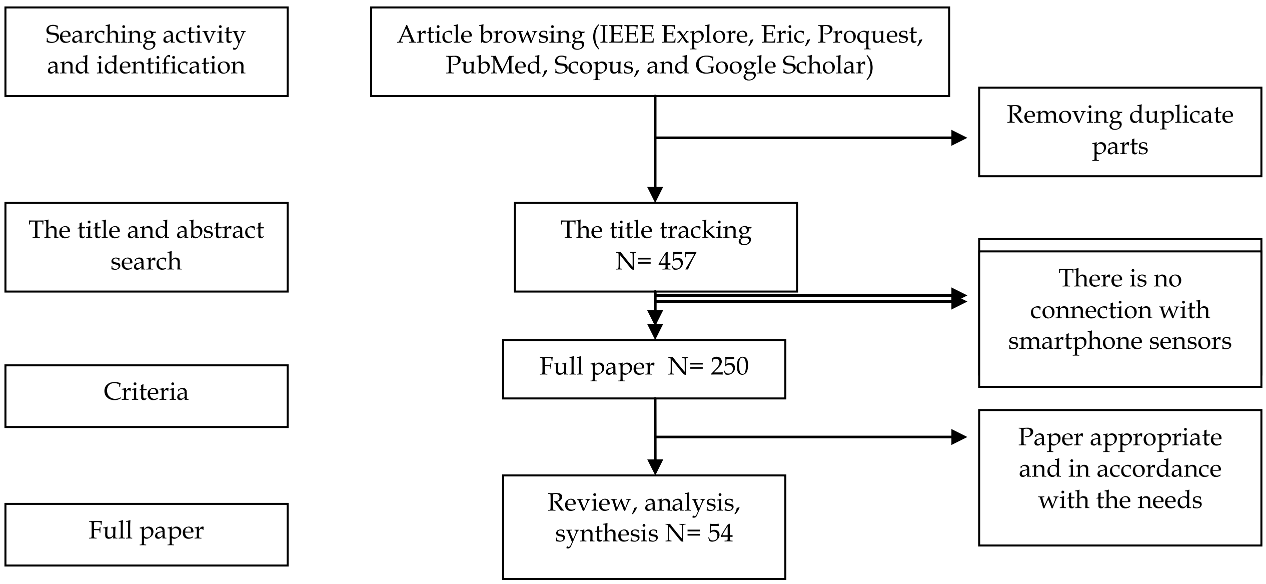

***Fig. 1**. The review procces*

The review process repeated regularly and gradually. The articles are investigated based on abstracts, methods, instruments, and technology used. The main discussion is about the use of smartphone sensors for learning physics. However, apart from that all of this article discusses more the types of smartphone-sensor sensors can be applied learning

3 RESULT AND DISCUSSION

Smartphones have presented their way in the modern world as a very flexible, adaptable and accessible tool designed for communication. Because of their portability, reduced size and several integrated functions, they have become indispensable accessories for the new generation. The application of cellular technology skills is an essential part of the learning process in modern schools. Educational experts now feature not only the integration of Cellular technology into the learning process but also the need to enhance the efficiency of the learning process for teachers and students. Success not only based on what or how much one knows, but also on one's ability to think and act creatively. The cellular technology-based learning process is based on Education Technology Competency Standards for Teachers and emphasises the requirement to develop teacher technology skills and with a focus on knowledge and capacity improvement [20]. Smartphones have fast processors and large touch screens, smartphones have enhanced platforms that can be used to move where students can quickly learn educational element and process experimental data. Most smartphones use the Android operating system, which allows access to the Google Play Store, a digital platform where users can download many applications to use on their mobile phones. This paper provides comprehensive information about applications that have the potential for education in physics courses in the classroom. With using a smartphone, it is essential to study Physics using the built-in sensor of the cellphone for data acquisition to processing and interpret it. This aspect utilises a smartphone into an indispensable instrument for the teaching of physics. Especially in smartphone devices there are several applications that can help teachers in the teaching and learning process, including such as force measurement, linear accelerometer, gyroscope, barometer, roller coaster, ruler, magnetometer, compass, global positioning system, stroboscope, inclinometer, light meter, color detector, sound meter, tone generator, silo scope, spectrogram (audio) spectrum analyzer, multi-media, color generator [21], [22].Here are presented the forms of sensors found on Android that can be used in the learning process, especially physics learning As presented in Table 1.

TABLE 1
UTILIZATION OF VARIOUS SENSORS IN LEARNING PHYSICS

Name author	Years	Aplication name	Device	Function
Jun Wang and Wenqing Sun [23]	2019		Spectrometer sensor	Used in diffraction experiments with anti-peeping protection films (PPP films) for privacy screen protectors that can stop other people peering at the screen of your smartphone.
Jennifer Groppe [24]	2011	Audacity®	Sound sensor	Used in physics teaching in class such as to visualize sound waves and understand the meaning of amplitude, frequency, and superposition
Wing-Kwong Wonga, Jia-Ming Xub, Tsung-Kai Chaoc [25]	2011		Acceleration sensor and orientation sensor	Can be used for some physics experiments such as projectile motion and pendulums.
Jochen Kuhn [26]	2012		Acceleration sensor and force sensor	Used to Determine the Acceleration of Gravity in Physics Class
Kyle Forinash and Raymond F. Wisman[27]	2012	Signalscope		Used to receive data from an external circuit. smartphones as portable oscilloscopes using available hardware and applications.
Patrik Vogt, and Jochen Kuhn [28]	2012	Accelogger	Acceleration sensor	Used to analyze simple pendulum phenomena
Asif Shakur, and Taylor Sinatra [29]	2013	xSensor	Gyroscope	Used to determine the angular momentum of an object
Juan Carlos Castro-Palacio, Luisberis Velázquez-Abad, Marcos H. Giménez, and Juan A. Monsoriu [5]	2013	Android Accelerometer Monitor versi 1.5.0	Acceleration sensor	Used in physics experiments on free and damped harmonic oscillations
Jochen Kuhn, Patrik Vogt [30]	2014	Kit Audio untuk iOS atau FuncGen untuk Android	Sound sensor and light sensor	Used in several physics experiments such as experiments to analyze gravitational acceleration and infrared diffraction remote control phenomena and acoustic experiments
Jochen Kuhn and Patrik Vogt [31]	2013	Audio Kit	Sound sensor	Used to explore various types of sounds using a microphone from a smartphone
Dinko Oletic and Vedran Bilas [32]	2013		Sensor Node	Used for air quality measurement
J A Sans, F J Manj´on1, A L J Pereira, J A Gomez-Tejedor, and J A Monsoriu [4]	2013	Physics Toolbox Light Sensor	Ambient light sensor	Used to to analyze the system of two spring pairs which experienced modest or damped oscillation movement
E. Ballester, J.C. Castro-Palacio, L. Velázquez-Abad, M.H. Giménez, J.A. Monsoriu, L.M. Sánchez Ruiz [33]	2014	Accelerometer Monitor ver 1.5.0.	Sensor accelerometer smartphone	This application shows the ax, ay, and az acceleration components on the x, y and z axes at each time step. This application also allows storing output files, from which data can be retrieved for further analysis.
Monteiro, Cecilia Cabeza and Arturo C Mart [34]	2015	AndroSensor	Acceleration and rotation sensors	Used to make measurements directly from acceleration and the angular velocity of the pendulum and rotational motion.
Manuel Á González. ,M. Esther Martín , Cármen Hernández , M. Á. González, Jesús Vegas, Mar Herguedas, César Llamas , Óscar Martínez [9]	2014	Accelerometer Monitor, Audia	Acceleration sensor and sound sensor	Can be used in conducting several physical experiments such as measuring acceleration components along the up and down in the elevator
Jochen Kuhn, Patrik Vogt, and Andreas Müller [35]	2014	iOS: mis. SPARKvue4; Android: mis. Accelogger5	Acceleration sensor	Used to analyze elevator oscillations
Martín Monteiro, Cecilia Cabeza, Arturo C. Marti, Patrik Vogt, and Jochen Kuhn [36]	2014		Sensor: Kionix KXTF9 three-axis accelerometer	used to determine the relationship between angular velocity and the relationship of centripetal acceleration

Name author	Years	Aplication name	Device	Function
Hrebesh M. Subhash, Josh N. Hogan, and Martin J. Leahy [37]	2015	tomografi koherensi optik (OCT)		Used in the world of health such as measuring vital user parameters such as heart rate, breathing rate, glucose, and body temperature.
Manuel Á. González, Juarez B. da Silva, Miguel Á. González, Willian Rochadel, Óscar Martínez, Juan C. Cañedo, Diego Esteban, Félix Huete & Javier Manso [38]	2015	Sensor mobile dan audio	Accelerometer, gyroscope, magnetometer, sound, light,	Used to do several physics experiments that utilize smartphone sensors such as tone experiments on vibrating rods of various shapes and compositions
Enrique Arribas, Isabel Escobar, Carmen P Suarez, Alberto Najera and Augusto Beléndez [39]	2015	Magnetometer (iOS), Magnetometer Metal Detector, dan Physics Toolbox Magnetometer (Android)	Magnetometer sensor	Used to measure magnetic fields in practicum physics
Michael Hirth, Jochen Kuhn, and Andreas Müller [35]	2015	SpectrumView Plus	Spectrogram Sensor	Used to determine the speed of sound with a high degree of accuracy using everyday tools.
Martín Monteiro, Cecilia Stari, Cecilia Cabeza, and Arturo C. Marti [40]	2017	Vernier Graphical Analysis	Accelerometer sensor	Used to conduct Atwood Machine experiments
Matthaios Patrinopoulos and Chrysovalantis Kefalis [41]	2015	Fisika Toolbox Giroskop	Gyroscope sensor	used to measure direct angular velocity and moment of calculation of inertia from rigid objects.
Stefano Macchia [42]	2016	Android: Physics Toolbox Sensor Suite, Sensor Suite, DS Barometer; untuk iOS: Barometer & Altimeter, Bar-o-Meter, Barometro Pro)	Barometric sensor	used to release the pressure exerted by water on a smartphone that is summarized in a bucket full of water
Ray Pörn and Mats Braskén [43]	2016	Android Androsensor	Gyroscope sensor	used to read and measure objects that spin dynamics in permanent rotation
Pablo Martín-Ramos, Manuela Ramos Silva and Pedro S. Pereira da Silva [44]	2017	Fast Burst Camera Lite	Acceleration sensors and light sensors	Used to perform experiments related to the motion of projectiles
Martín Monteiro, Cecilia Cabeza, Cecilia Stariand Arturo C. Martí [45]	2017		Barometer sensor, light sensor, magnetometer sensor, accelerometer	Used in several experiments such as the use of smartphone pressure sensors to measure vertical speeds of elevators, stairs and drones. use of light sensors and orientation sensors in the Light Polarization and Malus Law experiments. use of magnetometer and accelerometer sensors in the 'flyby' magnetic field measurement experiment. and the use of sound sensors in experiments A bottle of tea as a universal Helmholtz resonator.
R D Septianto, D Suhendra and F Iskandar [46]	2017	Keuwlsoft	Magnetic sensor	used to measure magnetic fields, electric currents in two forms of wire, straight and circular
Serkan Kapucu [47]	2017	AndroSensor	Light sensor	Used to find the average speed of a light-emitting car toy
Sameer Arabasi and Hussein Al-Taani [48]	2017	Magnetic Field Detector, Magnetometer, dan Teslameter	Magnetometer sensor	Used to measure the slope angle of the Earth's magnetic field

Name author	Years	Aplication name	Device	Function
Qiang Liu, Yun Liu, Huizhen Yuan, Fang Wang, and Wei Peng [49]	2017		Resonance sensor, Sensor Ag / Au bilayer SPR sensor	used to determine the surface of a red-green dual optical fiber
Azael Barrera-Garrido[50]	2017	Tracker		used to determine the balance of smartphone inertia
S Staacks , S Hütz, H Heinke and C Stampfer [6]	2018	phyphox'	Accelerometer, gyroscope, magnetometer	used to perform several physical experiments such as pendulum and spring
Unofre Pili and Renante Violanda [51]	2019	Physics Toolbox Sensor Suites.7	Magnetic field sensor	Used to calculate the spring constant
Catalin Florea[52]	2019		Sound sensor	To analyze brief sounds
Peter F. Hinrichsen[53]	2019		Microelektromeks (MEM) Accelerometer Sensor	Calculating acceleration, speed, and displacement for magnetically dampened oscillations
Yen-Heng Lin, Chien-Hung Chiang, Min-Hsien Wu, Tung-Ming Pan, Ji-Dung Luo, and Chiuan-Chian Chiou [54]	2011	BioFET	Solid-state sensor	Used to measure glucose and creatinine in blood serum.

The functions of mobile devices to teach physics like two complementary lines. In addition, this article presents the types of sensors and applications that are connected to smartphones that can be used in physics learning. the aim is to make it easy for teachers or students to use smartphones in learning. The author presents several types of smartphone sensors that can be directly downloaded by the teacher or student through the playstore on each smartphone.In various physical phenomena, smartphones have the benefit of better electronics and built-in sensors, such as accelerometers, gyroscopes, magnetic sensors, or light detectors, which enable their owners to practice them as analysis tools for experimenting and learning. Next, physics teachers can further use this second characteristic to increase the collaboration of student learning by designing real experiments at a low cost using a smartphone. Next, pupils and teachers will be able to manage smartphones as a measurement device both in learning labs and in several other projects, where students can employ content studied in class.. For example, we exploit the use of digital smartphone gyroscopes to study paired oscillator systems and present research similar using a light sensor around the smartphone [55]. In addition, you can also use a smartphone microphone to measure Doppler effects in sound waves. Another example the teacher can use a smartphone to measure the period of oscillation of objects as shown in Fig. 1.

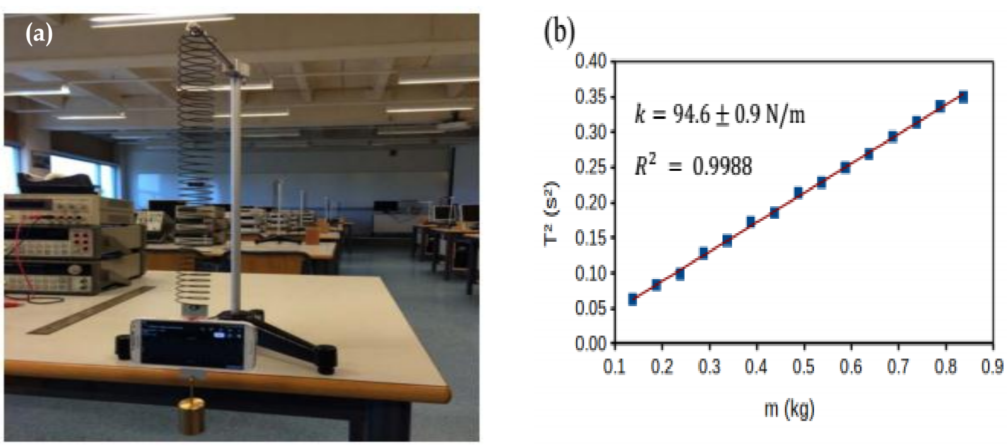

***Fig. 2**. (a) an experiment to measure the period of spring oscillation, (b) graph the relationship between T^2 (S^2) and masa [4]*

With using smartphone sensors in physics, learning allows students to carry out experiments without having to do it in the laboratory room. The smartphone is very suitable as an experimental tool because it has several sensors. For example, most smartphones involve microphones as well as sensors for acceleration and field strength, the density of light sensors and GPS receivers. Because all sensors can be read by the appropriate software (application), a large number of quantitative school experiments can be done with a smartphone. One example, many smartphone applications are integrated into one like phyphox (Physics Toolbox) (see Fig. 2). Phyphox helps students or teachers to use sensors in smartphones to experiment in class. For example, it is detecting the pendulum frequency using an accelerometer or estimating the Doppler effect using the microphone.

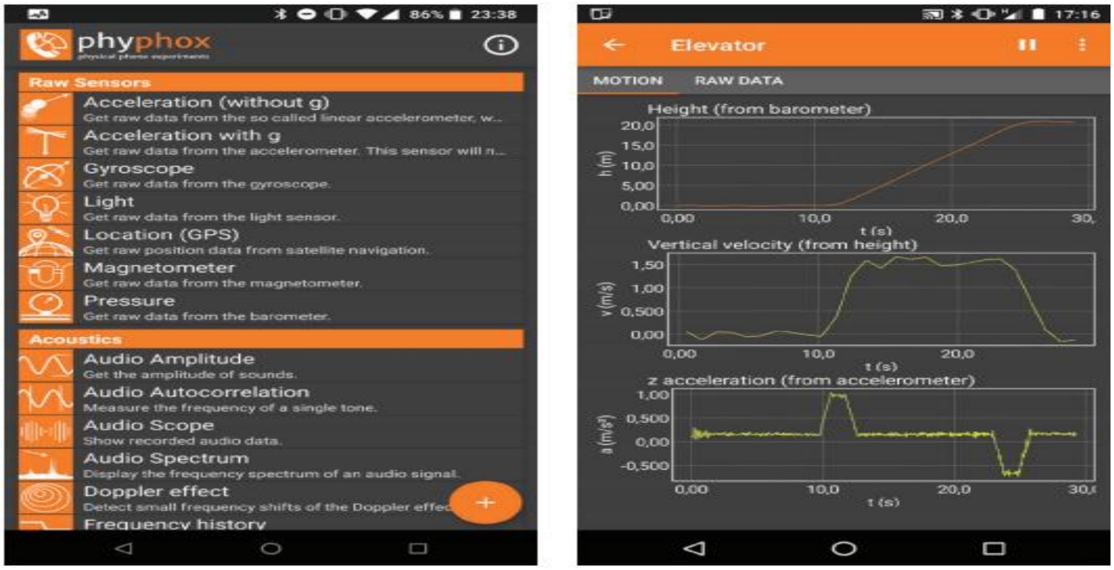

__Fig. 3__. Phyphox display [6]

By utilizing phyphox sensors in physics, learning can help teachers do experiments without having to spend a lot of energy and costs. IThe phyphox application provides various types of sensors that are useful for calculating the acceleration of gravity, impact, pressure, gyroscope, magnetometer, and light sensor. In addition, the results of experiments using phyphox can be connected with Microsoft Excel so that it is easier to carry out the analysis process. Therefore, the presence of various types of applications and sensors in smartphones can make it easier for teachers to do teaching and can enhance collaboration between teachers and students.In addition, Ballester et al. [30] reported that the use of smartphone sensors in learning is very supportive in learning physics at school. In this, he employed in physics learning by conducting circular motion experiments using acceleration sensors. He demonstrates that smartphone acceleration sensors show the practicability of utilising these sensors in physics learning experiments. In his study, he gave examples for several types of one-dimensional motion where acceleration plays an essential role in identifying systems such as oscillation and circular motion and the study of one-dimensional oscillation can comfortably extend to two-dimensional oscillation.On the other hand, studies of rotational motion can be easily applied to study circular movements that uniformly accelerated by using, for example, rotator disks that connected to a hanging object by using a pulley. Other sensors such as ambient light sensors and magnetic field sensors can also integrate with physics teaching experiments. Another case with Escobar, he argued that smartphone sensor blended into an integrated system that allows us to know the position, provide information, speed, acceleration, time, acoustic level, and other different physical quantities. Escobar et al [56] tried to use a smartphone sensor to magnetic field learning. In this because magnetic field learning is complicated without simulation assistants or media. He assumed that each current perpendicular to the magnetic field produced a small potential difference, transversal to that current because the Hall sensor quickly measured this voltage. With the application of the three Hall sensors and the suitable application, we can easily estimate the three elements of the magnetic field vector, and get information and infer the characteristics of the physical system under consideration. Whereas Setiawan et al., [57] measure magnetic fields in the form of 2-dimensional vectors using a smartphone sensor. The results of the study concluded that an economical smartphone magnetic sensor has an excellent ability to accurately measure the components of the magnetic field in a magnetostatic experiment and is very suitable for the study of physics in particular magnetization material that can be used to move where students can quickly learn educational element and process experimental data. The resulting is an experimental design conducted by Setiawan et al., as presented in Fig. 4

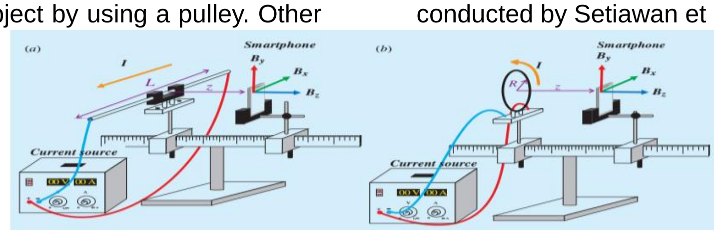

__Fig. 4.__ Experimental design created by setiawan et al., [57]

By using a design created by Setiawan, the authors assume that it will be easier to get the measurement results precisely. In this helps students and teachers understand the concepts of physics, especially in magnetic fields. It can also develop in order to improve students' science process skills in terms of assembling tools, arranging equipment and others. Therefore the role of smartphone sensors in learning is significant. Smartphone sensors exist to provide convenience and practicality to help students understand the concepts of physics. The smartphone is here to help students bridge the gap between students' daily lives and the world of experiments. The application of smartphones also bypasses the use of remote laboratory tools that are known to frustrate focus on the intended content.

4 CONCLUSION

Smartphone technology can bring important changes in the way we teach and learn. In this article the use of smartphone sensors to conduct experiments and measurement of physics easily. From these results it was found that the development of smartphone sensor applications is present as a new and useful complement to traditional teaching, because they enable them to reach multimedia devices easily, and learn about anytime and anywhere. Smartphones combine theoretical concepts, simulations, and self-evaluations to control students to get by showing them what concepts or systems need to strengthen. This application can also practice as support in laboratory work carried out by pupils, each by providing them to access remote experiments or by appending additional information, such as by using enhanced truth, to information available in the laboratory.

ACKNOWLEDGMENT

Would like thanks to all those who helped analyze various articles, so that this article can be completed. The author hopes that the writing contained in this article can be used and utilized by teachers and students

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