



# **The Development and Perception of Trainee Teachers towards Smartphone Based Free Fall Measurement Kit Using Arduino**

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## **Authors' contributions**

*This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.*

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## **ABSTRACT**

Free fall motion is one of the topics that is always considered challenging for Physics Students. The lack of teaching aids concerning this topic is also why students are less exposed to the free fall concept. Thus, this study aims to develop a Free Fall Kit as a teaching aid for the Physics Form Four under the subtopic Free Fall Movement. This kit is developed using an Arduino microcontroller where the result of gravitational acceleration will be displayed on the smartphone through the Bluetooth module. This study also aims to test the trainee teacher's perceptions of majoring in physics at Universiti Pendidikan Sultan Idris towards the Free Fall Kit. The validity study was conducted with three experts among the physics lecturers at the Sultan Idris University of Education. These validity data were analyzed using the Percentage of Consent. The validity value obtained showed a high value where the total percentage of validity agreement from the three experts was 98.3% for face validity and 93.3% for content validity. This study uses a descriptive method to assess the instrument reliability and respondents' perceptions of the developed kits. The data obtained showed that Cronbach's Alpha value is 0.97, while an average mean score is 3.82 and an average standard deviation value is 0.28, indicating that the level of reliability and perception is at a high level of agreement among the respondents. In conclusion, the Free Fall Kit has a good perception among trainee teachers at Universiti Pendidikan Sultan Idris and has achieved the objectives of this research. The implication is that the Free Fall Kit can be an alternative teaching aid for teachers to teach the subtopic of free fall motion to determine the value of gravitational acceleration.

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## 1. INTRODUCTION

Education in Malaysia plays an important role in producing a balanced and harmonious current generation in terms of physical, emotional, spiritual, intellectual and social aspects. Science Education in Malaysia is a field that encompasses knowledge, skills, scientific attitudes and values. Physics is one of the elective subjects for the science curriculum offered at the upper secondary level. In educational institutions, the Physics curriculum plays a vital role in producing students who have knowledge and skills in technology and physics and can solve problems and make decisions in daily life based on scientific attitudes and values. The topic of force and motion is one of the topics covered within the form four physics subjects in Malaysia. This topic often considered difficult and requires a high level of understanding to comprehend [1]. Among the subtopics covered in the topic of force and motion is free fall motion.

According to Nordin (2019), in his study of students' problems in learning physics to link the concept of physics with actual phenomena, students are usually confused and cannot visualize the physics phenomenon of acceleration that causes motion [2]. Only 35.48% of students answered correctly otherwise, the remaining 64.52% answered incorrectly. The alternative of using radical clocks was deemed to be inaccurate for determining the value of gravitational acceleration,  $g$  [3]. One of the efforts in understanding the concept of physics requires the help of learning media such as teaching aids (TA) during teaching and learning sessions (TnL). TA can aid students to understand the concept of physics that is from abstract to concrete [4]. The use of traditional methods such as chalk and blackboard is no longer relevant to the current educational developments. The introduction and implementations of technologies in education provides numerous platforms to students should be priorities of teachers [5]. Therefore, teachers need to implement the use of technologies during their TnL sessions.

The use of teaching aids in the TnL process is a very important medium for a teacher to speed up the process of student understanding of a subject and improve the quality of teaching. Therefore, the Free Fall Kit was proposed to solve students difficulty in mastering the concept of free fall motion. This study was implemented to achieve

the objective of the study which is to develop a Smartphone based Free Fall Measurement Kit using arduino as a teaching aid for the subtopic of free fall and test the perception of trainee teachers on this developed kit.

## 2. MATERIALS AND METHODS

### 2.1 Free Fall Measurement Kit

The Arduino Microcontroller has been used in this study with the primary purpose being to build a kit that is easy to carry and use. Fig. 1(a) shows the block diagram of the kit, where it consists of two infrared (IR) sensors, and the output will display on the android smartphone. Fig. 1(b) shows the circuit diagram, where the IR sensors are connected to PIN 7 and 9. IR sensor emits the light to sense some objects of its surroundings.

For the kit setup, two infrared sensors were placed on the top and bottom of a rod stick with a distance of 120 cm between the two infrared sensors as shown in Fig. 2 (a-b). The IR sensor will detect the object released at the starting point passing through the points of IR 1 and IR 2. The time spent passing both the sensors will be measured, starting at point IR 1 and ending at point IR 2. The value of gravitational acceleration,  $g$  will be calculated based on the time value,  $t$  which is recorded by the arduino. Using the bluetooth module, the gravity acceleration value,  $g$  will be displayed on the smartphone screen via the RemoteXY application. Fig. 2(c) shows the RemoteXY application used and the display value of  $g$ .

### 2.2 Research Design

The ADDIE model was used as the primary reference in the development of this kit. The ADDIE model consists of five phases: analysis, design, development, implementation, and evaluation. In the analysis phase, the researchers conducted a literature review to identify the problems in education. As stated in the study problem statement, student's mastery for the concept of gravitational acceleration is at a low level where students usually feel confused and unable to visualize the phenomena of acceleration physics [2]. During the design phase, the researchers sketched the Free Fall Kit. The development phase of the research involves the researchers developing the Free Fall Kit as discussed in the previous section. Next, in

the implementation phase, the researchers obtained validity from three experts, while attaining the reliability and perception aspects from the respondents among the trainee physics teachers involved. As for the evaluation phase, the researchers analyzed the actual study data obtained to determine the level of trainee teachers' perceptions of the developed kits.

## 2.3 Research Population and Sample

The population in this study consisted of trainee physics teachers at the Sultan Idris University of

Education. The sampling method is done using the cluster random sampling method. Based on Table 1, the study sample is divided into three groups, depending on the sampling purposes. The validity of experts involved three experts, whereas the reliability of instrument, which will be pilot test, will involve 15 respondents. The perception toward kit, on the other hand, will involve 30 trainee physics teachers. According to Roscoe (1975), a total of 30 respondents is sufficient to perform most studies if the study population consists 30 to 500 individuals [6].

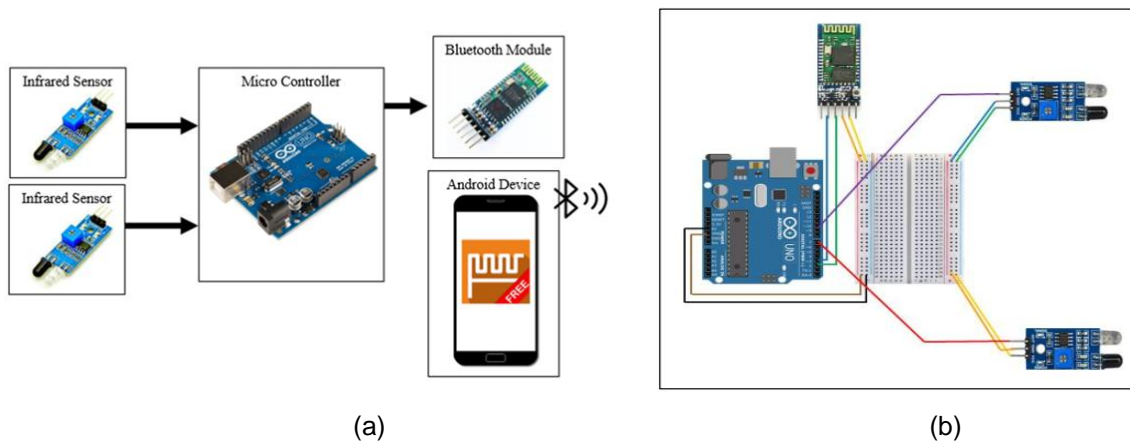


Fig. 1. (a) The block diagram (b) Circuit diagram of free fall kit

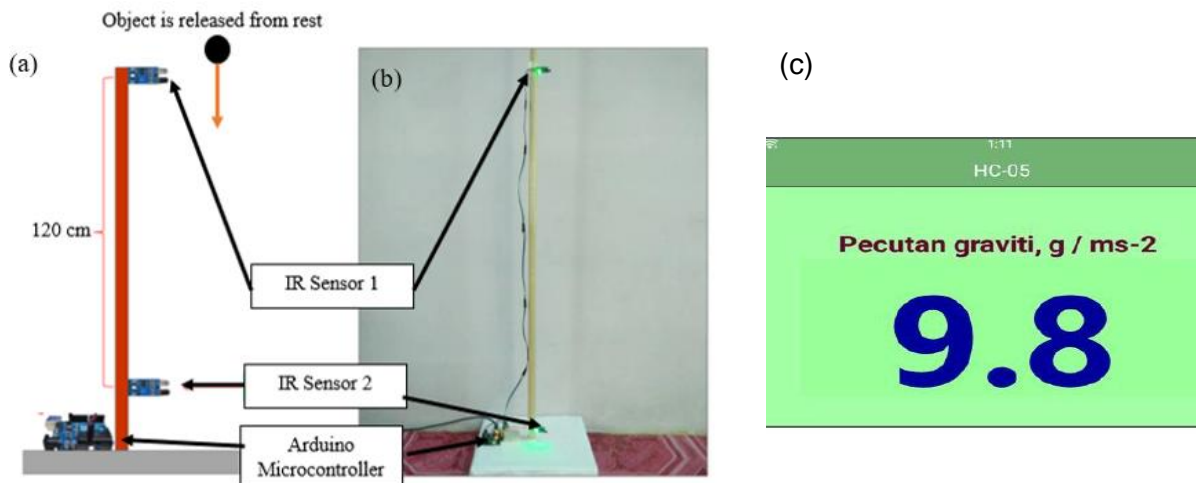


Fig. 2. (a) The illustration of free fall measurement kit (b) The developed free fall kit and (c) The real time data, where the value of gravitational force display on the smartphone

Table 1. Demographic information of respondents according to purpose and phase of involvement

No	Purpose of Sampling	Phase involved	No. of respondent
1	Expert validity	Implementation	3
2	Instrument reliability	Implementation	15
3	Trainee teacher's perception	Evaluation	30

## 2.4 Research Instrument

This study uses two types of instruments, namely expert validity assessment form and perception questionnaire form. An expert validity assessment form was used to review the validity of the product while a perception questionnaire form was used to test the usability perception of the kits developed in this study. The perception questionnaire form was adapted and modified from the USE questionnaire form [7]. The questionnaire is divided into four parts: part A on the respondents' information, part B on usefulness, part C relates to ease-of-use aspect, and part D involves the product satisfaction aspect. Sections B, C, and D use a four-point Likert scale with one to four values.

## 2.5 Data Analysis

The Percentage of Consent were analyzed to study the validity of the kit. Reliability and perception data were analyzed using Statistical Package for Social Science (SPSS) to obtain Cronbach's Alpha value to determine the level of instrument reliability while mean score and standard deviation to determine the level of trainee teachers' perception of the Free Fall Kit developed.

## 3. RESULTS AND DISCUSSION

### 3.1 The Validity of Force Measurement Kit

A product validity evaluation form was used to obtain data on the validity of the Free Fall Kit developed in this study. The researcher has obtained validation from three experts who are physics lecturers at the Sultan Idris University of Education. There were ten items on the face validity section and five items on the content validity section that used a four-point Likert scale that had a value of one to four. The researchers determined the validity value of a product by analyzing the data obtained using the percentage of agreement.

The study results from the product validity evaluation form found that the average percentage of agreement for the three experts was 98.3% for face validity and 93.3% for content validity (Table 2). It has been explained that the achievement level of 70% is considered to having mastered or achieved a high level of achievement and suitable for use [8]. Therefore, the validity with a value of 90% is considered having reached a high level of achievement.

## 3.2 Reliability of Instrument

This study conducted a pilot testing process prior to the actual study to collect data. A pilot test can be referred to as a small test that needs to be conducted to assess feasibility, time, cost, reversal effects or adverse effects, and the size of its effects in order to improve the study design before carrying out the actual research [9]. The pilot test conducted in this study helps the researcher undergo the actual data analysis process to achieve the study objectives. In the pilot testing process, the reliability and feasibility of the questionnaire formed will be reviewed and improved based on the respondent's feedback. Questions that are unable to achieve the objectives of the study will be discarded.

**Table 2. Average percentage of agreement for kit validity**

	Face validity percentage (%)	Content validity percentage (%)
Expert 1	100.0	80.0
Expert 2	100.0	100.0
Expert 3	95.0	100.0
Average	98.3	93.3

Cronbach's Alpha is a statistic that is generally used by researchers as a measure of reliability to ensure that the constructed questionnaire instruments are approved for research purposes in actual studies [10]. Reliability data were analyzed using a questionnaire form. The researcher has obtained the level of reliability through a questionnaire from 15 respondents, who are prospective physics teachers in the 7<sup>th</sup> semester at Universiti Pendidikan Sultan Idris. The analysis of the study findings from the questionnaire found that the average value of Cronbach's Alpha is 0.975 (Table 3). The highest Cronbach's Alpha value is 0.977 for the satisfaction aspect followed by 0.975 for the usefulness aspect and 0.973 for the ease-of-use aspect. According to Taber (2018), a reliability value is accepted if the Cronbach's Alpha value exceeds 0.8. Therefore, the level of reliability of the questionnaire instrument is at a high level [10].

### 3.3 Trainee Teachers Perceptions of Free Fall Kits

Questionnaires were used to obtain data on trainee teachers' perceptions of the Free Fall Kit developed. It was filled by 30 respondents who are prospective physics teachers in 6<sup>th</sup> and 8<sup>th</sup>

semester at Universiti Pendidikan Sultan Idris. The researcher has analyzed the study findings using mean scores and standard deviation values to determine the respondents' level of agreement. Based on Table 4, the results of the analysis of the study findings for each aspect of the Free Fall Kit were developed in the questionnaire, namely the aspects of usefulness, ease of use, and satisfaction are at a high level of agreement. Physics trainee teachers who had a high level of perception for aspects of usefulness (mean = 3.82, standard deviation = 0.308). Physics trainee teachers agreed that the Free Fall Kit is helpful for teachers to teach the concept of gravitational acceleration. It can also be used to engage students, increase students' understanding of the topic, and reduce the time required in comprehending the topic of Gravity Acceleration and also be used to improve students' performance for Physics subjects. This indicates that most of the respondents agreed that the aspect of the usefulness of the Free Fall Kit can be utilized as a medium to improve the TnL process. This is in line with research conducted by Hamdan & Jasmi (2014), stating that teaching aids can help teachers convey a topic taught better [11].

**Table 3. Instrument reliability level**

Items category	Cronbach alpha
Usefulness	0.975
Easy-to-use	0.973
Satisfaction	0.977
Average Cronbach Alpha	0.754

**Table 4. Average mean scores and average standard deviation value for each aspect**

Items category	Mean score	Standard deviation
Usefulness	3.82	0.308
Easy-to-use	3.78	0.275
Satisfaction	3.87	0.264
Average	3.82	0.282

Furthermore, the physics trainee teachers who also had a high level of perceptions for the easy -to -use aspect (mean = 3.78, standard deviation = 0.275). There are five items in the ease-of-use aspect. Trainee physics teachers agreed that the Free Fall Kit is easy to use and can be used anytime and anywhere, having a flexibility feature. Furthermore, the user manual contained in the Free Drop Kit is user -friendly. The trainee teachers felt that they could use the Free Fall Kit successfully at all times. This indicates that the

majority of the respondents agreed with the easy -to -use aspect i.e. the Free Fall Kit is easy to use in the TnL process. This is in line with the research conducted by Boimau and Mellu (2019), where a study on the development of microcontroller-based TA was carried out [12]. The use of TA in the learning process can reduce difficulties, make the planning of TnL sessions run smoothly and information retrieval becomes easier.

Finally, physics trainee teachers also had a high level of perceptions for the aspect of satisfaction (mean = 3.87, standard deviation = 0.264). There are five items in the aspect of satisfaction. Physics trainee teachers are satisfied, enjoying the use of the kit, having the urge of owning the Free Fall Kit, having intentions to use the kit when teaching Gravity Acceleration in the future, and recommend the Free Fall Kit to their friends and colleagues. This indicates that most of the respondents agreed in the satisfaction aspect of the Free Fall Kit developed as TA in the TnL process. Overall, the results of the analysis of the study findings from the questionnaire showed the average value of the mean score for all three aspects being 3.82. A mean score value between 3.00 to 4.00 is a good value as it is a high level of evaluation given by the respondents [13]. The mean value of the standard deviation for all three aspects was found to be 0.282. Standard deviation values ranging from 0.00 to 0.75 indicate a very high level of agreement by respondents [14].

#### 4. CONCLUSION

This study developed a Free Fall Kit that has an excellent perception among trainee teachers of Universiti Pendidikan Sultan Idris as a teaching aid in the subtopic of Free Fall Movement. The validity values obtained from the three experts showed a high level of agreement where the total percentage of validity agreement was 98.3% for face validity and 93.3% for content validity. The Cronbach's Alpha value obtained for the pilot study was 0.97, indicating a high level of reliability. Furthermore, for the actual study, it was found that the average mean score value was 3.82 and the average standard deviation value was 0.282 indicating that the level of perception was at a high level of agreement among the respondents involved. The implication is that the Free Fall Kit can be used as an alternative teaching aid for teachers to teach the subtopic of free fall motion to measure the value of gravitational acceleration.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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