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Development of Physics Providers Based on Arduino Uno Assisted with Infrared Sensors on Viscosity Materials

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The aim of this research is to (1) produce an Arduino Uno-based physics teaching aid product with the help of an infrared sensor on viscosity materials, (2) to test the feasibility of the developed teaching aid, (3) to determine the practicality of the developed teaching aid, (4) to find out responses from students regarding the teaching aids developed. The model used in this development is the 4D development model of Definition (Define), Planning (Design), Development (Development) and Dissemination (Dissemination). The feasibility test was carried out by two material expert lecturers and two media expert lecturers, the feasibility test carried out by two material expert lecturers received a percentage score of 98% in the "Very Eligible" category, and the feasibility test carried out by the media expert lecturer received a percentage score of 94 .17% with the category "Very feasible". Distribution was carried out to teachers to assess practicality and students to obtain responses from students regarding the teaching aids being developed. The practicality score carried out by two physics teachers received a practicality percentage score of 94% in the "Very Appropriate" category and for responses from students, the average response percentage score was 93% in the "Very Practical" category. So it can be concluded that the Arduino Uno-based teaching aids assisted by infrared sensors for viscosity materials are very feasible and practical to use during learning.

Keywords: Props; Arduino Uno; Viscosity; Infrared Sensor; Student Respon

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INTRODUCTION

In the learning process there are important components that influence the success of students' learning, namely (1) learning materials, (2) learning atmosphere, (3) learning media, (4) teaching aids, (5) learning resources, (6) teachers as learning subject (Af'idah et al., 2023). The learning process will be very beneficial for students if it can involve students directly in it, because this process can reduce students' misconceptions. One learning media that can involve students in the learning process and also make it easier for teachers to provide students with an understanding of the material is in the form of teaching aids.

The use of teaching aids in the learning process can enable students to gain direct knowledge and develop their own insights (Permatasari et al., 2019). Teaching aids are an alternative medium for observation and experimental activities and are able to provide active learning (Siti, 2019). Teaching aids are also simple tools that are shaped according to material needs, making learning more interesting.

The development of teaching aids can be made by taking advantage of advances in science and technology which have produced various electronic devices which help in developing props. There are several electronic devices that are important in developing teaching aids, for example microcontrollers, detector or sensor devices, display or LCD devices, and actuator devices (Azhar, 2020). With various existing electronic devices, the resulting design of teaching aids is more effective, efficient and has better accuracy of measurement results and visualization (Azhar, 2020).

There are several studies that have developed teaching aids using electronic devices specifically for viscosity materials, such as the research carried out (Br Depari et al., 2024). The viscosity demonstration tool uses a mini reed switch magnetic sensor based on an Arduino Uno equipped with a magnetic ball as a liquid viscosity meter and is considered very good for student perception, but the drawback is in the sensor used (mini reed switch magnetic sensor) the sensor does not have an LED so the user cannot find out whether the sensor is working properly or not; Development of a microcontroller-based viscosity modeling tool equipped with a rotating shaft to make it easier for students to collect data. This development is able to increase students' mastery of concepts, but the drawback of this development is the lack of initial calibration, thereby reducing the accuracy of the tool (Yunita, 2022). Development of teaching tools viscosity using a time sensor is able to train science process skills in high school students (Setyowati & Sucahyo, 2020). The development of Arduino-based basic physics experiment teaching aids 1 on viscosity material can be very suitable for use as a learning medium, but there are still things that need to be improved for further development, namely by choosing tubes with better materials, not used tubes from neon lamps to minimize damage to the tube that will be used to hold the fluid (Yunita, 2022).

From several researchers who have developed teaching aids on average viscosity materials using two tubes with different liquids equipped with one ball as a falling object in the liquid without any variations in different balls (mass) and the existing teaching aids are considered less practical because they are not easy to use. carried everywhere because the electronic circuit is made separately from the tube. So we need props that are more practical and can be moved to the desired location. However, in general, the teaching aids for viscosity materials used in schools still use tubes made from used fluorescent lamps and the time counters used still use stopwatches, making it possible for inaccuracies in time measurements of viscosity to occur.

From these shortcomings, the researchers developed a teaching aid which was also made from electronic devices with viscosity material, using two tubes made from plastic tubes with different liquids which were relatively smaller in size and also made from wood which was formed into a box as a tube holder as well as a place for the Arduino Uno and Arduino Uno circuits. The LCD both functions to detect falling balls with the help of an infrared sensor and also functions to display the time and speed of the ball falling in each liquid in the tube and the props developed can also vary the mass of the ball with the help of an artificial filter to replace balls of different masses. This teaching aid can also be easily carried anywhere and can also easily change the fluid in the tube because the viscosity box can be opened when operating and closed when finished so it is safe to maintain the equipment because the electronic circuit used is put together in a small special circuit box. However, not only that, the advantage of this development also lies in the fluid and tube which can be easily replaced with other fluids, because the placement of the sensor is not combined with the tube, so it is very possible to change the fluid whose viscosity will be measured.

The aim of this development is to produce a teaching aid product and determine the feasibility, practicality and response from students regarding the development of an Arduino Uno-based physics teaching aid aided by an infrared sensor for material viscosity.

METHOD

This type of research is research into the development of physics teaching aids on viscosity materials. The method used in this research is the research and development method using the 4D model (Define, Design, Development and

Dissemination) developed by (Rizki et al., 2016). This method was chosen because the results that the researchers will develop will be in the form of physics teaching aids on viscosity materials. The following steps for research and development on 4D models which produce products in the form of props can be explained in this section:

[Figure 1 about here.]

The first stage is definition. At this stage the researcher carries out a needs analysis obtained through interviews sourced from physics teachers to support development needs. After the needs analysis, it is continued with a literature study. There are 9 references used related to the research title, which are consisting of 6 national articles and 3 books. After stages 1 and 2 are completed, development goals can be set.

The second stage is designing. Selecting materials and designing a design that suits the material or needs and also estimating the materials and expenses needed. The teaching aid developed is an Arduino Uno based viscosity demonstration aided by an infrared sensor. The components consist of 2 plastic tubes with different liquids, 4 infrared sensors, electronic circuits, artificial filters, marbles and wood.

The third stage is development. At this stage, after the researcher has finished developing and producing the product, the feasibility test will continue by carrying out validation tests by validators, where in this development the researcher uses 2 material expert validators and 2 media expert validators. The four validators were given questionnaires to fill out according to the teaching aids developed

The final stage is Dissemination (Dessiminate). At this stage the researcher carried out a distribution with tests obtained from two physics teachers to assess the practicality of the teaching aids developed by providing a questionnaire consisting of 13 statements and a second limited test obtained from class XI students of Al-Islamiyah High School who totaling 21 students to find out the responses given by students to.

The validation instrument data analysis technique used by researchers is the Likert scale. The distribution of Likert scale scores can be seen in the following table 1.

[Table 1 about here.]

After dividing the assessment scores, proceed with analyzing the data using the following equation:

$$P\ (s) = \frac{s}{N} X\ 100\%$$

Information:

P(s) : Percentage of sub variables

S : Total score for each sub variable

N : Maximum total score

Next, determine the validity criteria based on the percentage criteria with the interpretation guidelines used in the following table 2:

[Table 2 about here.]

The criteria for the practicality of teaching aids developed by teachers can be seen in the following table 3:

[Table 3 about here.]

Finally, the assessment criteria obtained from student responses can be seen in the following table 4.

[Table 4 about here.]

RESULT AND DISCUSSION

Results

This development research produces an Arduino Uno-based physics teaching aid product assisted by an infrared sensor that can measure the time and speed of a ball falling in different liquids. The following is a picture of the electronic design (hardware) and a picture of the results of developing the teaching aids that have been developed.

[Figure 2 about here.]

[Figure 3 about here.]

Figure 3 is a design of an electronic device to activate the LCD and sensors. The electronic design is packaged using a black box which can be seen in figure 2. The development of the props in figure 2 contains two tubes containing different liquids, sensors to detect the time and speed of the falling ball, an LCD to display the lift time and speed and filters. contained in the tube serves to make it easier to pick up the ball in the tube that has been dropped. The following are the results of the feasibility test, practicality and responses from students regarding the teaching aids developed.

a. Results of validation of teaching aids by material experts

The results of the validation assessment carried out by 2 material expert validators on the development of Arduino Uno-based physics teaching aids assisted by infrared sensors consisting of 11 statements using 3 aspects can be seen in the following figure 4:

[Figure 4 about here.]

Based on the graphic image of the assessment by material experts in figure 4, it is known that in the suitability aspect, valiator 1 gets a feasibility percentage of 90%, validator 2 gets a feasibility percentage of 100%. From the convenience aspect, validator 1 gets a feasibility percentage of 100%, validator 2 gets a feasibility percentage of 100%. And in the aspect of connection with teaching materials, validator 1 got a percentage of 95%, validator 2 got a feasibility percentage of 100%. As forThe results of testing the teaching aids for material experts were the average value for each validator, namely validator 1 received a feasibility percentage of 95% in the "very feasible" category, validator 2 received a feasibility percentage of 100% in the "very feasible" category. The average of the two validators for these 3 aspects received an average score of 98% in the "Very Appropriate" category by making revisions or improvements on a small scale.

b. Results of validation of props by media experts

The results of the validation carried out by two media expert lecturers on the development of Arduino Uno-based physics teaching aids assisted by infrared sensors on viscosity materials by providing a questionnaire consisting of 14 statements using 5 assessment aspects can be seen in the following table:

[Figure 5 about here.]

Based on the assessment results in figure 5, it can be seen that in the aspect of tool durability, validator 1 got a feasibility percentage of 85%, validator 2 got a feasibility percentage of 95%. For the accuracy aspect of the tool, validator 1 received a feasibility percentage of 100%, validator 2 received a feasibility percentage of 95%. The efficient aspect of the tool is that validator 1 gets a feasibility percentage of 90%, validator 2 gets a feasibility percentage of 100%. The security aspect of the tool for users by validator 1 received a percentage of 100%, validator 2 received a feasibility percentage of 100%. And validator 1 got a percentage of the aesthetic aspect of the tool, and validator 2 got a feasibility percentage of 90%. The average value assessed by each media expert validator got a feasibility percentage of 93% in the very feasible category by making revisions, validator 2 got a feasibility percentage of 96% in the very feasible category by making revisions. On average, the media expert validator assessment results received a percentage of 94.17% in the "Very feasible" category by carrying out revisions on a small scale. The results of improvements from suggestions and input by experts can be seen in the following table 5:

[Table 5 about here.]

c. Practicality questionnaire results by teachers

Before carrying out the trial, the first step taken by the researcher was to explain the instructions for using the teaching aids so that they could be applied to students, followed by giving a questionnaire to 2 physics teachers to assess the practicality of the teaching aids which consisted of 13 statements using 4 aspects. The following are the results of the practicality scores by the teacher:

[Figure 6 about here.]

Based on the graphic image, the average percentage of assessments obtained can be seen in the practicality aspect, with teacher 1 getting a practicality percentage of 95%,
teacher 2 getting a practicality percentage of 100%. For the effectiveness aspect, teacher 1 received a practicality percentage of 85%, teacher 2 received a percentage of 90%. For the material aspect, teacher 1 received a practicality percentage of 95%, teacher 2 received a practicality percentage of 100%. And in the learning design aspect, teacher 1 got a percentage of 100%, teacher 2 got a practicality percentage of 95%. for the average percentage of practicality by each teacher, that is, teacher 1 got a practicality percentage of 94% in the very practical category without revision, and teacher 2 got a practicality percentage of 96% in the very practical category without revision. The overall average practicality score for teaching aids by teachers received a practicality percentage of 94% in the "Very Practical" category.

d. Results of student response questionnaires

The second stage of distribution was aimed at students to find out responses from students regarding the development of Arduino Uno-based physics teaching aids assisted by infrared sensors. Class XI Al-Islamiyah students, totaling 21 students, were given a questionnaire consisting of 14 statements using 4 aspects of assessment. The following are the results obtained from student responses:

[Figure 7 about here.]

From the graphic image of the average percentage of student responses in each aspect above, it can be seen that in the ease aspect, the response percentage was 94%, the display aspect received a response percentage of 92%, the quality aspect received a response percentage of 92%, and in the learning aspect, the response percentage was 92%. the response percentage was 93%. The overall response percentage for these 4 aspects was 93% with the response category being "Very

Positive". The responses from students regarding the teaching aids that were developed were that these teaching aids were suitable and good to be used as learning media because they were very easy to operate and they could easily understand the material.

Discussion

Based on Figure 2, it can be seen that this research produced a product in the form of an Arduino Uno-based teaching aid assisted by an infrared sensor for material viscosity. In this research, the researcher attempted to perfect the development of previous relevant research, the teaching aid developed was equipped with 2 tubes containing different liquids, marbles with different masses, 4 sensors placed in each upper and lower tube, a butane filter to collect a ball that has been dropped into a liquid.

This physics teaching aid in viscosity material can measure time and speed for each fluid used. When collecting data, researchers create a fixed distance between the upper sensor limit and the lower sensor limit to make data collection easier. When a marble is dropped, the sensor will detect it, indicated by the LED on the sensor turning on, both when it passes through sensor 1 and sensor 2. Then when the marble passes through sensor 2, the time and speed of the falling ball will automatically be detected and displayed via the LCD. . The following LCD image displays the time and speed of the falling ball.

[Figure 8 about here.]

The feasibility test by material expert validators from all aspects received a very feasible category, which can be seen in diagram 5. This shows that the teaching aids developed are in accordance with the content of the material, are easy and related to learning. This is in line with research conducted by (Hasanah, 2016; Kaltsum, 2017) which states that the suitability of the material is the main thing and an important consideration in developing tools. This is also in line with research conducted by (Kania, 2018) who states that it is important to present material in accordance with teaching aids to make it easier for students to understand the material so that there are no errors/misconceptions in it.The connection between teaching aids and teaching materials is also very important because it can make it easier and motivate students to recognize, accept, absorb and understand the relationship between knowledge concepts and values or actions contained in the material (Zahroh, 2023).

The feasibility test by media experts also received a very feasible category from all aspects, this is because the overall percentage of validators is very important to the props and received a score above 80%. This is in accordance with research (Nomleni & Manu, 2018) which states that the results of this research are supported by previous research which states that the percentage of all aspects by validators influences the level of feasibility of a development product. This is also in line with other research which states that the overall percentage of media experts must be more than 80% to be considered appropriate and valid to be used as support for the learning process (Nomleni & Manu, 2018).

Furthermore, the practicality value also received a very decent category, this is because the tool developed uses the help of sensors to make it easier and automatically record the time and speed of the falling ball and of course the time and speed are more accurate. This is in accordance with the opinion of (Br Depari et al., 2024; Nurvitasari & Admoko, 2019) that a sensor-assisted viscosity display tool will make it easier to collect time and speed data automatically and will also be more accurate. With this development, it will be more practical to carry out practicums because they can also be used by students who cannot operate stopwatches and minimize inaccuracies in the data obtained. Also agrees with previous research that one of the main factors causing the lack of accuracy of the data is measuring the travel time of objects which is relatively fast but only uses a stopwatch through ordinary eye observation (Yunita, 2022).

CONCLUSION

Based on the results of the development which produced a product in the form of an Arduino Uno-based physics teaching aid aided by an infrared sensor on viscosity material, it can be concluded that the teaching aid is very suitable for use with an average percentage score obtained from material expert lecturers of 98%, from media expert lecturers also getting a category. very worthy with a percentage score of 94.17% in the very worthy category. The practicality score obtained by the teacher obtained an average percentage score of 94% in the very practical category, and for the average percentage score obtained by students, students got a percentage of 93% in the very positive response category. It is hoped that further research will test the effectiveness of Arduino Uno-based physics teaching aids with the help of infrared sensors on this Viscosity material on a wider scale, covering students' cognitive abilities or science process skills.

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

LIST OF TABLES

TABLE 1 / Validation Questionnaire Assessment Scores

No	Information	Score
1	Strongly agree	5
2	Agree	4
3	Neutral	3
4	Don't agree	2
5	Not really worth it	1

(Sugiyono, 2015)

TABLE 2 / Props Eligibility Criteria

Evaluation	Interpretation criteria
81 < 100%	Very worthy
61 < 80%	Worthy
41 < 60%	Decent enough
21 < 40%	Not feasible
0 < 20%	Not feasible

(Sugiyono, 2008)

TABLE 3 / Criteria for the practicality Level of the Tool

Practicality Scale	Criteria
81-100%	Very Practical
61-80%	Practical
41-60%	Quite Practical
21-40%	Less Practical
0-20%	Impractical

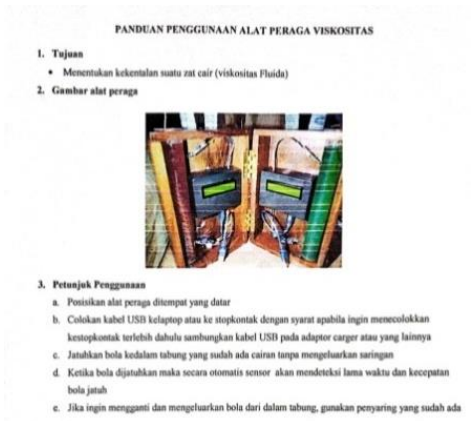
(Sugiyono, 2008)

TABLE 4 / Sudent Response Criteria

Student Response Interval	Criteria
80 < 100%	Very positive
60 < 80%	Positive
40 < 60%	Pretty positive
20 < 40%	Not positive
0 < 20%	Very less positive

(Arikunto, 2010)

TABLE 5 / Before and After Revision

Before revision	After revision
 Use a stopwatch to measure the time the ball falls	 Uses sensors to calculate fall time as well as speed
 The sensor is not provided with safety	 The sensor is provided with a safety guard to avoid damage to the sensor from water splashes and so on
 PANDUAN PENGGUNAAN ALAT PERAGA VISKOSITAS 1. Tujuan • Menentukan kekentalan suatu zat cair (viskositas Fluida) 2. Gambar alat peraga 3. Petunjuk Penggunaan a. Posisikan alat peraga ditempat yang datar b. Colokan kabel USB kelaptop atau ke stopkontak dengan syarat apabila ingin menecolokkan kestopkontak terlebih dahulu sambungkan kabel USB pada adaptor carger atau yang lainnya c. Jatuhkan bola kedalam tabung yang sudah ada cairan tanpa mengeluarkan saringan d. Ketika bola dijatuhkan maka secara otomatis sensor akan mendeteksi lama waktu dan kecepatan bola jatuh e. Jika ingin mengganti dan mengeluarkan bola dari dalam tabung, gunakan penyaring yang sudah ada The tool usage guide uses language that is difficult to understand	 PANDUAN PENGGUNAAN ALAT PERAGA VISKOSITAS 1. Tujuan • Menentukan kekentalan suatu zat cair (viskositas Fluida) 2. Gambar alat peraga 3. Petunjuk Penggunaan a. Letakkan alat peraga ditempat yang datar b. Kabel USB disambungkan ke adaptor untuk untuk dihubungkan kesumber tegangan atau kabel USB dapat langsung disambungkan kelaptop c. Bola dijatuhkan kedalam tabung yang berisi cairan tanpa mengeluarkan saringan d. Ketika bola dijatuhkan maka secara otomatis sensor akan mendeteksi lama waktu dan kecepatan bola jatuh e. Catat hasil waktu dan kecepatan bola jatuh yang ditampilkan dilayar LCD f. Gunakan penyaring untuk mengeluarkan bola dari dalam tabung Catatan: Tabung yang terdapat dalam alat peraga tidak diletakkan secara permanen, (Tabung dapat diambil dengan mudah dari kotak alat peraga tersebut) yang artinya apabila pengguna alat peraga ingin mengukur kenkentalan cairan yang berbeda maka dapat dengan mudah mengambil tabung dan menggantinya dengan cairan yang lain. The tool usage guide uses language that is easy to understand

LIST OF FIGURES

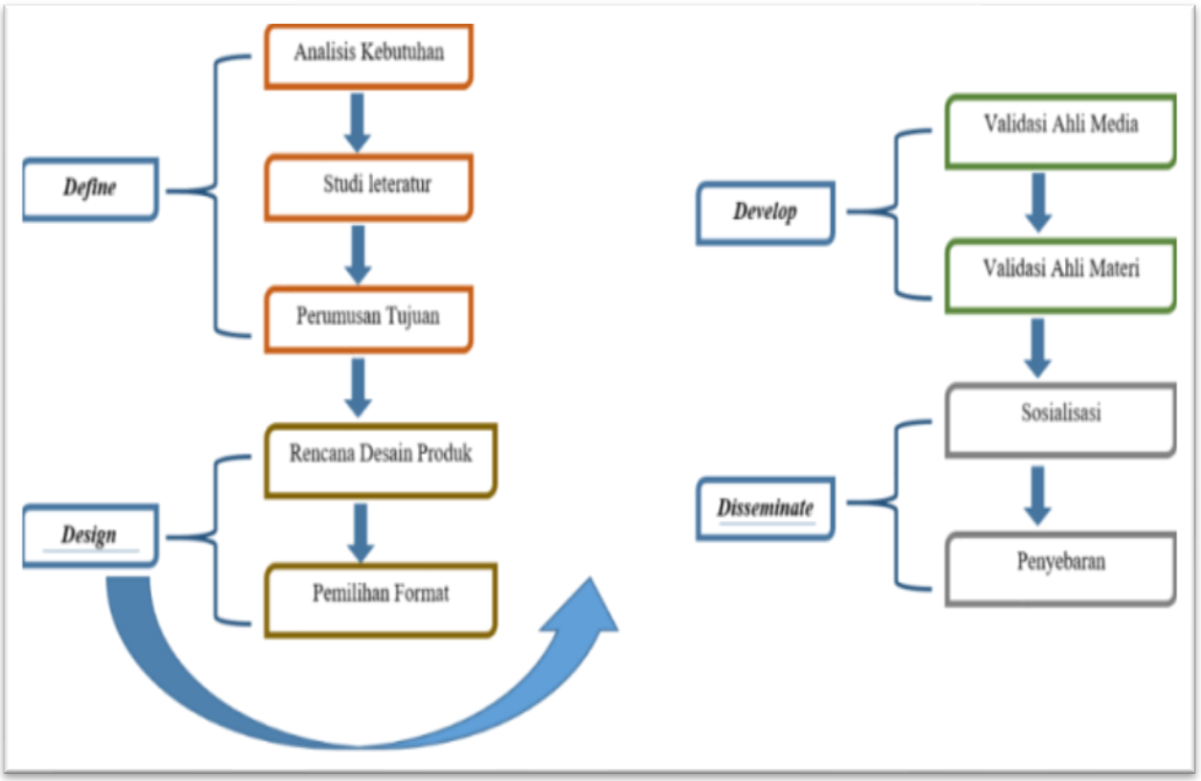


FIGURE 1 / 4D Model Development Chart

FIGURE 2 / Ardunio-Based Teaching Aids

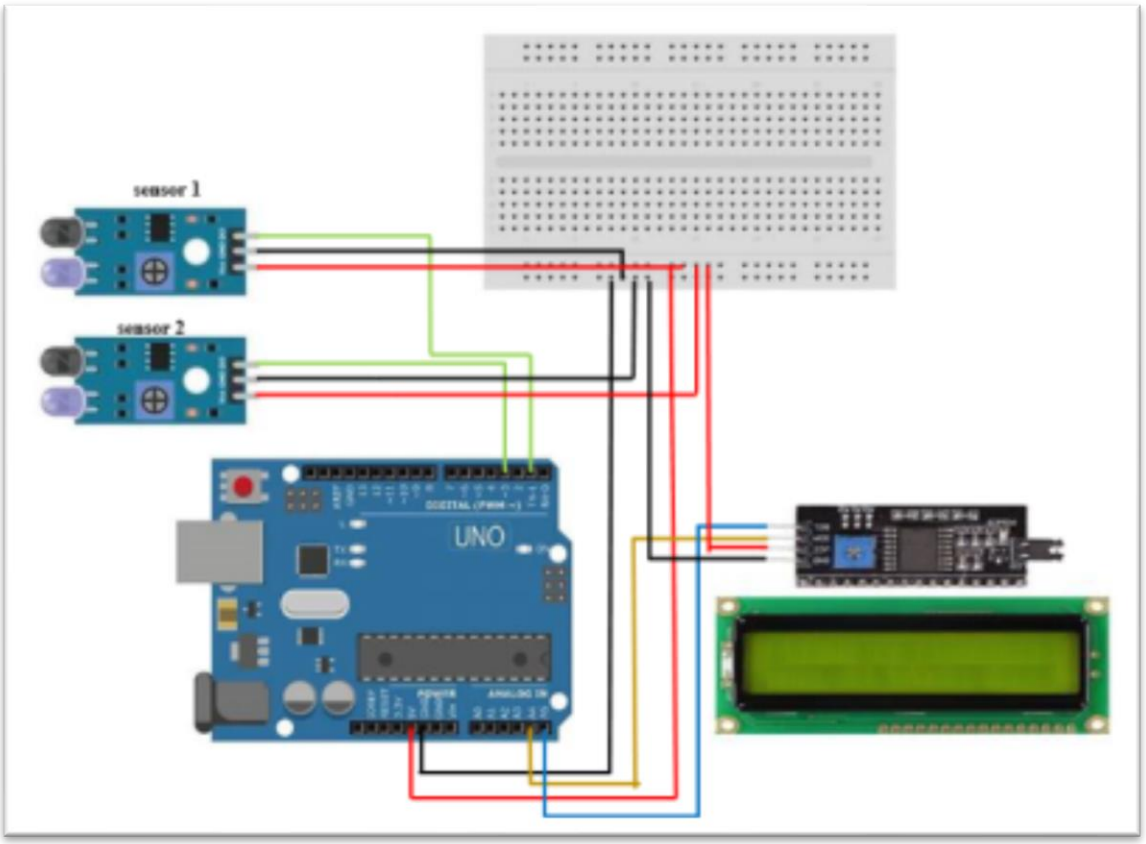


FIGURE 3 / Hardware

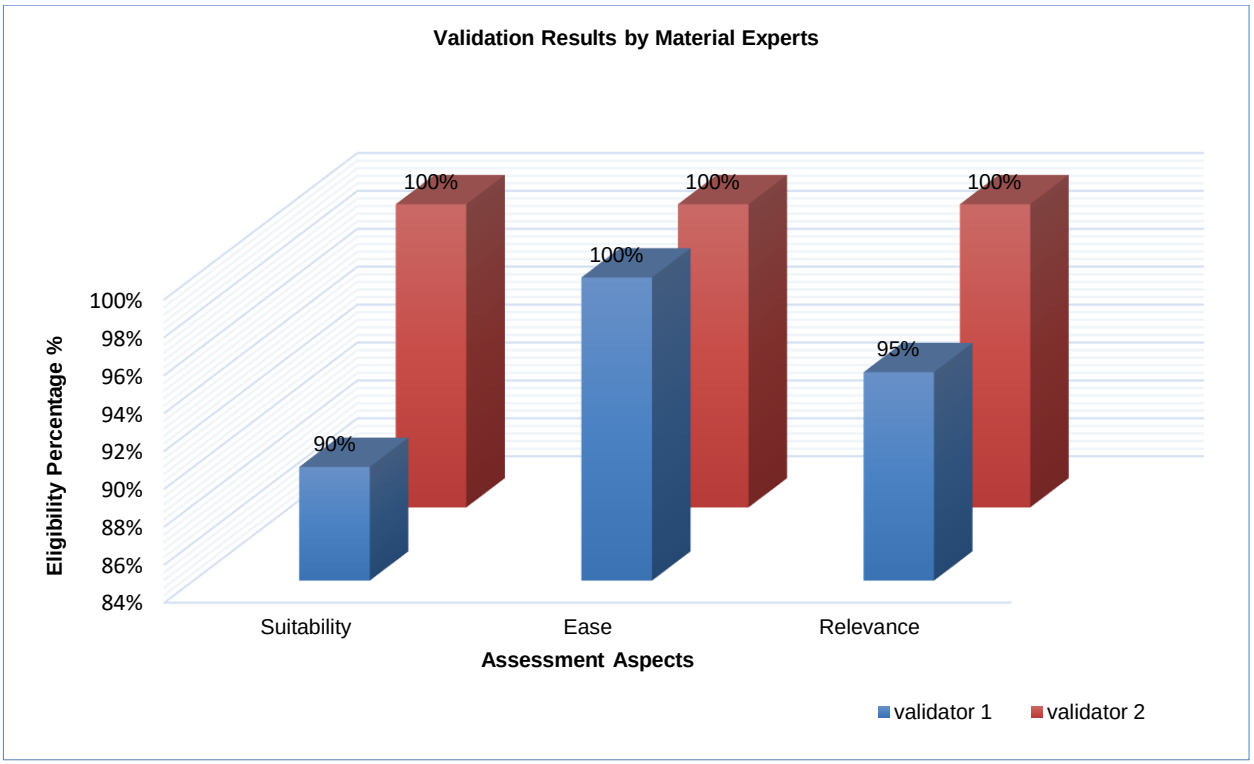


FIGURE 4 / Graph of the Percentage of Material Expert Assessments

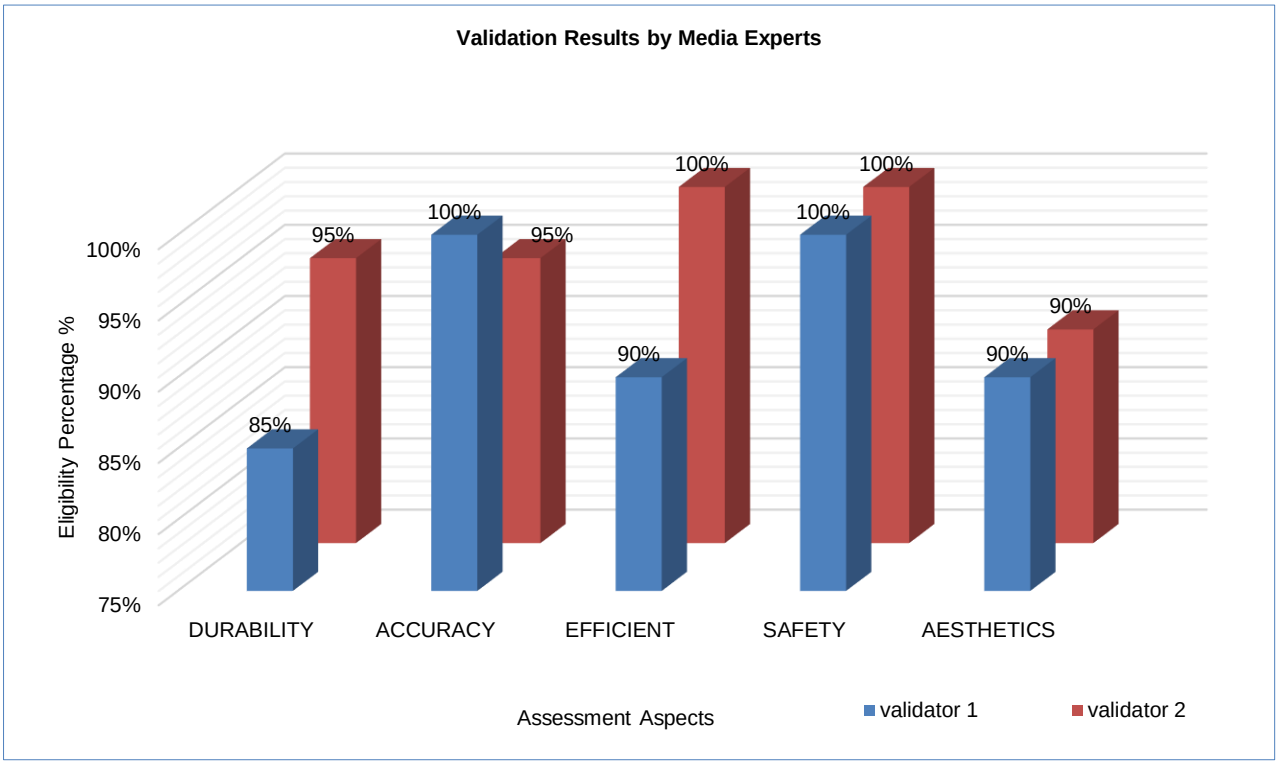


FIGURE 5 / Media Expert Assessment Percentage Graph

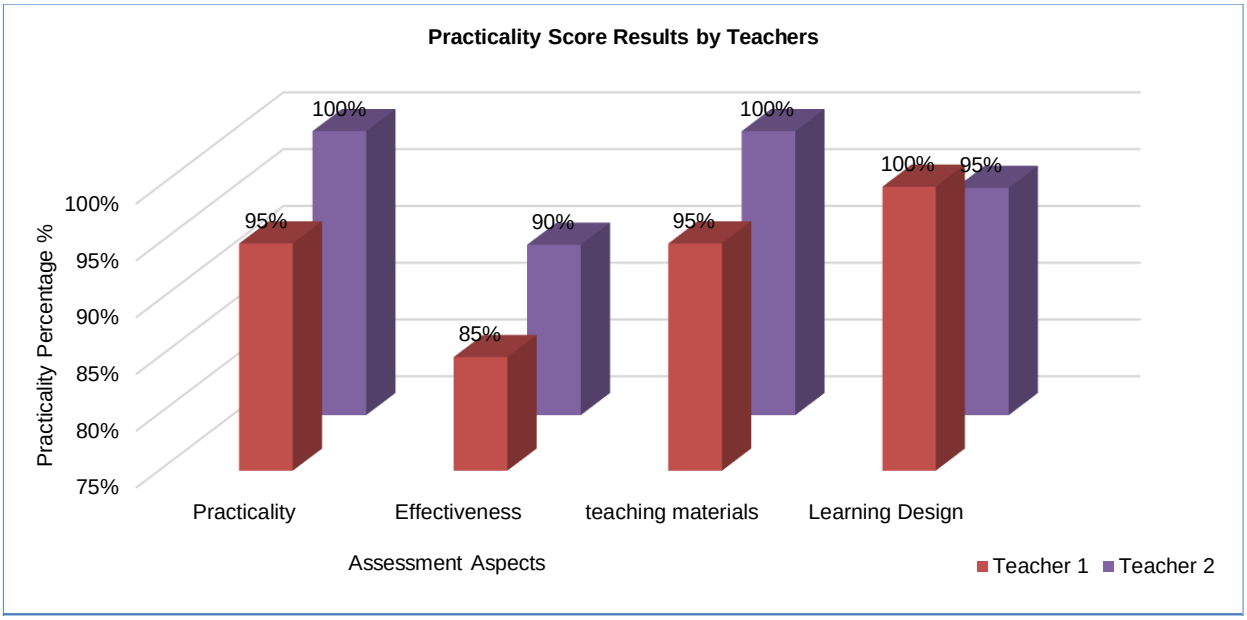


FIGURE 6 / Practicality Percentage Graph by Teachers

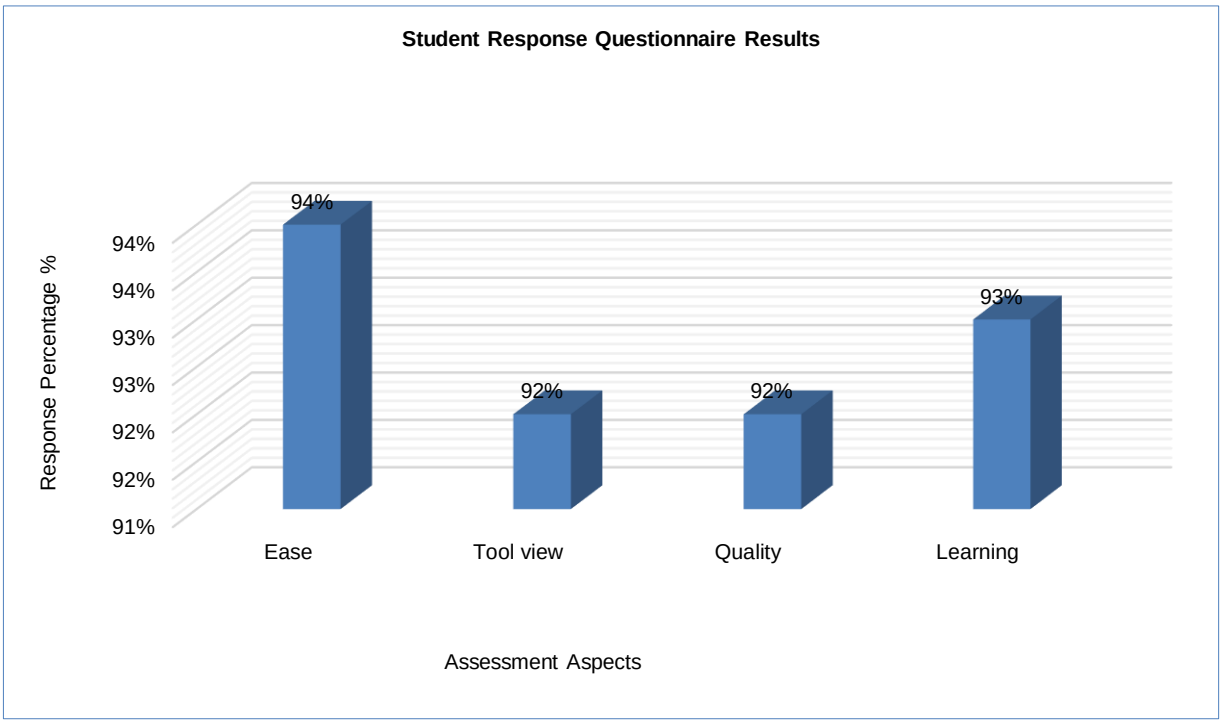


FIGURE 7 / Graph of Student Response Questionnaire Result for Each Aspect

FIGURE 8 / LCD Display