The Development of Viscosity Practice Tools Based on Information and Communication Technology Using Arduino and Android on Static Fluid Material for Grade XI Senior High School

D P Sandjaja¹, L Roza¹, M N Hidayat¹, F A Rosyid¹, and N Makdiani²

¹Physics Education Department, Faculty of Education and Teacher Training, University of Muhammadiyah Prof. Dr. HAMKA, Jakarta, Indonesia
²Mathematics Education Department, Faculty of Education and Teacher Training, University of Muhammadiyah Prof. Dr. HAMKA, Jakarta, Indonesia

*E-mail: liszulfahroza@uhamka.ac.id

Abstract. A difficult practicum activity has become a problem with students’ activities and lack of use on ICT-based practice tools, especially Android. The purpose of this research is to develop physics learning media in the form of practical tools and Android applications on static fluid material with a focus on viscosity. This research is development research by adopting the Borg & Gall development model. At the initial research and information gathering stage, the problem and needs analysis activities are carried out. In the planning stage, an initial design is carried out. During the initial product format development phase, the prototype is designed as a manifestation of the defined ideas and ideas. In the initial trial phase, the media are tested on material experts and media experts and then evaluated. At the field trial stage, the media were tested on a small scale with 30 respondents. Data obtained through the observation method were analyzed descriptively qualitatively. While the validation data were analyzed descriptively qualitative and quantitative. The average score of material expertise was 79.78% (good), media expertise was 82.59% (good), small scale test was 84.78% (good). So it can be concluded that this application is suitable for use as a medium for learning physics.

1. Introduction

Learning is a conscious effort that is conducted to change ideas which results in human behavior patterns. So someone is said to learn if he experiences a change in himself which is progressive and not a setback [1]. As explained by Arief S. Sadiman that learning is a complex process that happens to everyone and lasts a lifetime, from the moment he is born to die. One sign that someone has learned is a change in his behavior. These behavioral changes involve cognitive, psychomotor, and affective changes [2]. Educators are not the only source of learning even though their tasks, roles, and functions are very important. If judging the teaching profession history, teaching tasks is a delegation from the task of parents because they are no longer able to provide knowledge, skills, and certain attitudes in by the times [2,3]. With the development of science and technology, society and culture in general, the role and task of educators are developing along with the growing number of children who need
education [2]. On this day, the educator is emphasized as a facilitator to help students transform the potential or skills of learners obtained from educators or other learning resources. In the teaching and learning process, educators are required to be innovative so that students can gain new experiences in teaching and learning so the learning process becomes fun.

This innovation can be in the form of developing instructional media (educational technology) and learning methods. Development is carried out to create interesting instructional media. With interesting media and methods, it is expected to facilitate educators and increase student’s motivation and understanding in obtaining learning material [4]. So that education does not merely use conventional methods in the classroom and overcome the educator’s limitation, so learning is not monotonous. The innovations produced must be adjusted to the time. There have been many media developed in each year, but most of these media are already inadequate and considered ineffective in the current era because technology continues to develop rapidly every day. In essence as a practice, the actual technology of education is as old as the age of education itself. If education is as old as humans, then that is also as old as educational technology [5]. If the instructional media are already old, then it is appropriate to do an update that adapted to the paradigm of modern society. Many instructional media have begun to be replaced because they are considered to be less effective in use.

When traced back, several technological development milestones significantly contribute to the existence of ICT today, starting from the invention of the telephone by Alexander Graham Bell in 1875 to present [6]. When telecommunications equipment growing rapidly until now the analog technology has been replaced because it has shown the maximum limits of exploration. The digitalization of telecommunications equipment then converges with computer equipment. The convergence product available now is cell smartphones. on this telecommunications and computerized infrastructure multimedia can develop. This convergence that characterizes the 21st century while the 21st century there was a digital revolution in computing telecommunications in which machines replaced or enhanced the human brain [7].

The revolution of digital telecommunications computing can be seen from the growth of public needs for digital telecommunications and computing tools, for example, is a smartphone. Since four years ago, precisely in 2015, the Emarketer digital survey agency has estimated the number of technology uses will increase drastically throughout the world [8]. Indonesia is one of the top countries after China and India's smartphone growth. Every year from 2015 to 2019, Indonesia has increased in smartphone users approximately a dozen percent per year, which means that people's needs for smartphones are very high, either to support a learning activity or to meet other needs. According to Benny A. Priyabdiani in this modern era, technology has become an inseparable part of all aspects of human life [9, 10]. Technology, especially information technology has a very big influence on the way humans do a learning process. Information technology can act as a learning medium that is designed and developed to be able to convey information and knowledge needed by the audience [9].

By the growth of the smartphone market in Indonesia in recent decades, and with the closeness of humans to technology, especially smartphones, has unwittingly changed the pattern of learning that was originally limited heading in a more flexible direction. People can utilize technology media and carry out the learning process without being bound by time and space factors. The development of information technology has also produced many variations in the amount of media that contains information and knowledge that can be learned. Students and educators can choose a variety of media that can be studied according to the needs [11].

The observations made show that students use mobile phones more than any other media in the classroom. Data shows that 60% of students use mobile phones when learning compared to other learning media such as computers or laptops, books, worksheets, and instructional media. This proves the existence of a transition of habits that originally only relied on classical tools into modern tools by the times. In the past few decades, the use of mobile phones was strictly prohibited in the learning process, there were even schools that forbade students from using mobile phones in the school environment. But at this time schools have begun to experience changes and acceptance in the use of mobile phones in schools. The view of mobile phones that were originally negative in the school
environment slowly began to fade. According to Deni Darmawan, ICT at the high school has not yet become the main database for evaluation, curriculum, students, teachers, or others. But the prospect is bright enough to serve educational institutions specifically, it can also be used for education in general [7]. The needs, the analysis found that 87% of students use the Android operating system and the remaining 13% use the IOS operating system. This shows that users among students prefer the Android operating system to other operating systems. Furthermore, the observation also obtained data in the form of a percentage of students’ activities with their smartphones. The data obtained are browsing at 26%, social media at 25%, gaming at 13%, streaming at 17%, and learning at 19%. This is a challenge for educators to maximize smartphone’s functions so that students can also optimally use a smartphone as a learning tool.

According to Karsumi’s statement, physics in learning cannot be transacted solely through information transactions. Deep understanding can only occur through skill training and sometimes also through experience [11]. Skills training is a form of implementing material obtained in class. Skill training is needed to train students in real environments in daily life. Of course, skills training requires several tools to support the training process which is commonly referred to as a practical tool. However, in practice in the field, not all physics material can be implemented through a practicum. This happens because instructional media is too difficult to be applied in schools or even educators are confused about the current media. As shown in the observation that 90% of students have never done a practicum of viscosity.

2. Method
Research and development method used in this study. The Borg & Gall technique was used as a model in our study [12], however, in this study, this technique was adopted into eight steps, according to our requirements. In this study, instructional media that have been initially designed and then develop into practical tools. Furthermore, the practice tools then validated from two-person of material and media experts in their respective fields, respectively. Field tests from our practical tools were carried out with 30 respondent students from Bina Dharma High School. The aim of the field test is continuous to validate the developed media as can be seen in detail from figure 1.
Firstly the researcher gives a validation form that has already we arranged using Likert scale to students and expertise [13]. Then after they are filling the instrumentation, we continue to validate the result using calculation from the data that have been already they are filling with the equation below.

$$NP = \frac{R}{SM} \times 100$$

Information:
NP = Percentage Value
R = Value Obtained
SM = Maximum value
100 = Fixed value

The calculation of instruments could be converted in form of letter or predicate following the presented Table 1.
### Table 1. Percentage Value

| Mastery Level | Value | Score | Category   |
|---------------|-------|-------|------------|
| 86 s/d 100 %  | A     | 4     | Very Good  |
| 76 s/d 85 %   | B     | 3     | Good       |
| 60 s/d 75 %   | C     | 2     | Intermediate|
| 55 s/d 59 %   | D     | 1     | Bad        |
| ≤54%          | TL    | 0     | Worst      |

3. Results and Discussion

This development produced a set of instructional media called Viscosity. This instructional media is a viscosity practice tool that is connected to Android with Bluetooth intermediaries. This viscosity practice tool is the same as a conventional practice tool, but this tool has a hall effect sensor as a catcher to the magnetic characteristics of a falling ball. And then, the characteristics of a magnet will be translating by Arduino into time data in units of milliseconds. Meanwhile, the Android application on a smartphone is used as a visualization of the content and time data generated from the falling ball of the viscosity experiment that has been recorded by Arduino. So that the data produced is more accurate than the data produced by conventional viscosity practice tools.

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Meanwhile, for the oil liquid, the accuracy of 99.7% was obtained at a height of 32 cm. But if the ball is dropped at a height of 37 cm, accuracy decreases to 97.5%. Then at a height of 42 cm produces an accuracy of 99.4%, accuracy of measurement at a height of 42 cm is better than at a height of 37 cm, slightly reduced when compared to measurement data at a height of 32 cm. The coefficient of viscosity of water fluids has an accuracy of 99.21% when the ball is dropped at a height of 32 cm. However, at a height of 37 cm the oil viscosity coefficient has an accuracy of 97.50%. At a height of 42 cm, it produces an accuracy of 94.52%. From the results obtained, it can be seen in Figure 3 that the terminal velocity that occurs in the viscosity symptoms of oil, including the type of straight motion changes irregularly.

\[
Kr = \frac{\Delta x}{\bar{x}} \times 100\% \tag{2}
\]

\[
Kc = 100\% - Kr \tag{3}
\]

Information:

Kr = Relative Accuracy
\(\Delta x\) = Deviation
\(\bar{x}\) = Average of data
Kc = Accuracy
The results of this study are in accordance with the results of research conducted by Ridwan et al., which obtained a viscosity measurement deviation by 1.67% at a predetermined height which means that the time accuracy of the ball fell by 98.33% using water fluid [14]. The results of this study are also consistent with the results of the study reported by Nurry Putri Tissos, et al., Where they obtained a deviation value of viscosity measurement of 2.89% for oil fluid and 5.48% oil fluid which means that the accuracy of the ball falling on the oil fluid was 97.11% and 94.54% oil fluids [15].

3.1. Validation of Product
The Viscosity practice tool kit that was developed has done a feasibility test by two-person material expert and two-person media expertise, and then a small-scale feasibility test at Bina Dharma High School by students. This test aims to determine the feasibility of the viscosity tool which has been developed. The feasibility testing process is carried out by completing the validation instrument that was previously created. From the validity instrument, it produces quantitative data through an assessment of the validation instruments that researchers have given previously. While qualitative data is obtained from comments and suggestions from the expertise according to their field and opinions also suggestions from students as users. The results of this qualitative validation serve as guidelines for the development of the viscosity practice tool. Figure 3 explains the percentage diagram of material expertise eligibility on each aspect.
From the figure, it can be seen that the percentage of the feasibility of the viscosity tool in the opinion of the first material expert is 85.21% and belongs to a good category for the aspect of content eligibility. In the aspect of presentation, it has a feasibility of 70% with an adequate category and 80% in the language feasibility with a good category and in the contextual assessment, aspect has eligibility of 80% with a good category. Then in the second material expertise, the results of the percentage of the viscosity tool feasibility on the aspect of content eligibility were 77.08% in a good category, on the aspect of presentation eligibility resulted in an assessment of 70% with a sufficient category, the aspect of language eligibility resulted in an assessment of 77.78% with a good category, and in the contextual assessment aspect produces an assessment of 93% with a very good category. Meanwhile, the overall material expertise judgment was 79.48% with a good category.

From the figure, it can be seen that the percentage of the feasibility of viscosity tools in the opinion of the first media expertise is 90% and is classified as a very good category for the learning design aspect. In the aspect of writing, suitability has eligibility of 83.67% with a good category, on the aspect of the feasibility of the display of 83.67% with a good category and media aspect utilization has eligibility of 85% with a good category. Then in the second media expertise, the results of the percentage of the feasibility of the viscosity tool in the learning design aspect were 80% with a good category, the learning design aspect resulted in an assessment of 80% in the good category, in the display feasibility aspect it produced an assessment of 83.33% in the good category, and in the utilization aspect it produces an assessment of 80% in the good category. Meanwhile, the overall media expertise judgment was 79.48% with a good category.

3.2. Product Implementation
Viscosity tools that have been developed, are then improved in quality according to the directions, comments, and suggestions from material and media expertise, then implemented in small-scale tests on students. The implementation process is carried out by presenting the result of the viscosity tool and students try it as a respondent. Next, the respondents assessed the Viscosity tool that was developed through a validation instrument that had been previously distributed. Figure 5 shows the
percentage diagram of the results of the feasibility test of the tool on a small scale at SMA Bina Dharma.

![Diagram](image.png)

**Figure 6.** Percentage Diagram of Tool Feasibility Test Results on Small Scale at Bina Dharma High School

From the figure, it can be seen that the percentage of the feasibility viscosity tool according to the opinion of the first media expertise was 84.25% with a good category for the aspect of appearance. In the aspect of the content of the material amounted to the feasibility of 83.47% with a good category, on the aspect of media utilization amounted to 84.78% with a good category. In small-scale test activities also produce qualitative data in the form of respondents' comments and suggestions which are then used as an evaluation of the Viscosity tool which was developed.

### 3.3. Final Product Review

This learning media is a set of viscosity practice tools consisting of viscosity practice tools with a falling ball method and the Android application. The developed viscosity practice tool is a practice tool for the viscosity of falling ball methods in general, the difference is the hall effect sensor mounted on the practice tool and the Arduino system that works it. Meanwhile, the android application contains visual content of viscosity and visualization of experimental data on practicum activities. The developed application can be downloaded on the Google Play Store. The practice tools and applications developed here can be called Viscosity.
Figure 7. Front viscosity practice tool

Figure 8. Viscosity practice tool looks back

Figure 9. Main menu

Figure 10. Theory of viscosity menu
A. Tujuan
Tujuan yang harus dicapai dalam praktik viskositas, yaitu:
1. Memahami pengertian dari viskositas
2. Memahami jenis alat, prinsip dan cara pengukuran viskositas
3. Menentukan besarnya viskositas dalam percobaan
4. Menganalisa viskositas suatu fluida dari data hasil pengukuran

B. Alat dan Bahan
1. Perangkat alat praktik viskositas.
2. Bola magnet
3. Gelas beker
4. Neraca

C. Prosedur
Dalam percobaan ini, dilakukan 2 kali percobaan dengan menggunakan 2 jenis larutan yang berbeda.

Figure 11. Guidelines procedure menu
Figure 12. Bluetooth pair and visual data menu
Figure 13. Exercise menu
Figure 7 shows the viscosity practice tool from the front. In practice tool, there are two hall effect sensor, a hall effect sensor at the top can be moved up and down according to the desired height. Then on the front shows a tube containing oil and at the bottom there is a magnet to facilitate the sensor to read data. Meanwhile Figure 8 shows the back of the viscosity practice tool. On the back there is a box containing an arduino and a hall effect sensor drive lever. Meanwhile pictures 9 through 13 show the results of the android application.

3.4. Discussion
The Viscosity practice tool developed is an innovative learning media that has been adapted to ICT development. This practice tool consists of two tools, the first is a viscosity practice tool with the ball method and Viscosity application. With the Viscosity practice tool, the practicum process becomes more efficient and more thorough because it uses the hall effect sensor as a ball fall timer so the ball fall time is more accurate. And by using the Viscosity application, the lab becomes more interesting with the ease and supporting features contained in the application.

4. Conclusion
The development of a viscosity practice tool based on Information and Communication Technology using Arduino and Android on grade XI in static fluid subjects can be used as a source of learning and supports the learning process of static fluid subjects specifically the topic of viscosity. This instructional media can also be used as a learning tool in the learning process in the classroom and individually because it has been through a validation process by the expertise. This learning media is more efficient and can facilitate educators and students in the practicum because it is equipped with sensors that can produce accurate data and can replace the manual method.

References
[1] Nahar N I 2016 J. Ilmu Pengetah. Sos. 1 64.
[2] Sadiman AS 2016 Media Pendidikan, Pengertian, Pengembangan, dan Pemanfaatannya (Jakarta: Rajawali Pers)
[3] Fauzan 2016 An-Nizom I 135
[4] Woodcock B, Middleton A and Nortcliffe A 2012 Stud. Engagem. Exp. J. 1 1.
[5] Subkhan E 2016 Sejarah dan Paradigma Teknologi Pendidikan Untuk Perubahan Sosial (Jakarta: Kencana)
[6] Bruce RV 1973 Bell: Alexander Graham Bell and The Conquest of Solitude (New York: Cornel University)
[7] Darmawan D 2013 Teknologi Pembelajaran (Bandung: Remaja Rosdakarya)
[8] EMarketer 2015 Global Media Intelligence Report Executive Summary (New York: eMarketer) https://www.slideshare.net/FilippPaster/global-media-intelligence-report-2015
[9] Pribadi B 2017 Media & Teknologi dalam Pembelajaran (Jakarta: Kencana)
[10] Adesote and Fatoki 2013 Acad. J. 8 2155.
[11] Karsumi 2012 J. Pendidik. Fis. Indones. 8 8.
[12] Setyosari P 2013 Metode Penelitian Pendidikan & Pengembangan (Jakarta: Prenadamedia)
[13] Arikunto S 2012 Dasar-dasar Evaluasi Pendidikan (Jakarta: Bumi Aksara)
[14] Ridwan, Iskandar R and Nizar 2015 Pengembangan dan Aplikasi Viskometer (Jenis Bola Jatuh) Makalah SNMTK (Jakarta: Universitas Negeri Jakarta) 1
[15] Tissos N P, Yulkifli and Kamus Z 2014 J. Sainstek VI 71.