TORIQ: Android-based mobile learning for vector lessons

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Abstract. This research aims to produce an Android-based learning media using Adobe Flash CS6 Professional named TORIQ—Vector Intelligence Quiz. The product was developed by attention to aspects of validity, practicality, and effectiveness in X-grade students’ mathematics learning of Airlangga Health Vocational School of Balikpapan. The implementation used the design of MDLC model development which consists of concept, design, material collecting, assembly, testing, and distribution. The results were obtained from media testing consisting of Alpha 1 test, Alpha 2 test, Beta test in small group, and Beta test in large group. The results concluded that the Android-based TORIQ learning media that have been developed are included in the category of highly valid with a percentage of 86.928%, very practical with an average percentage of 85.208%; and effective with a percentage of completeness of 93.333%. Thus, as a whole, the TORIQ learning media developed can be an alternative media in learning activities, especially on vector material.

1. Introduction
The rapid development of Information and Communication Technology (ICT) is very influential in various fields of life [1]. This development has an increasingly open and spread of information and knowledge from and to all over the world through boundaries, distances, places, space and time [2], changing someone in communication, working, socializing, and learning [3, 4]. Not only that, the development of ICT is also widespread and has a positive impact on education [5-7]. For example, technology enriches the classroom with digital learning tools such as computer or laptop, interactive boards, and a lot of educational software [5]. Thus, elements in learning must be based on ICT so that the quality of education continues to improve, especially the adjustment of using ICT in the learning process [8-10].

Utilization of information technology is also used as a learning media to accompany the learning process at school or at home. The learning media used are expected to be able to motivate students to actively learn independently [7, 9]. Learning media is a tool to convey learning information and as a supporting factor for the achievement of learning objectives [8, 11]. Through learning media can clarify the message so that it is not too verbalism [12], improve students’ understanding and interest [5], as well as increasing motivation or student learning outcomes [13]. Learning media can also maximize the function of all students’ senses, so that weaknesses in one of the senses (for example: eyes or ears) can be balanced with other sensory strengths, and can clarify the theories / concepts of reality that are difficult to obtain [3].

Learning media can be designed in accordance with current technological developments. The Regulation of Minister of Education and Culture number 65 of 2013 [14] states that every teacher is
required to apply information and communication technology in integrated learning, systematic, and effective in accordance with the situation and conditions. Therefore, the application of information technology in learning is expected to improve the quality of learning. The development of technology-based learning media or commonly referred to as interactive learning media is one that can be done because this media can make learning more interesting. According to Maryani [15], interactive learning media with multimedia facilities such as images, animation and sound can be used as learning media so that students more easily understand the material presented. One of the interactive learning media that can be developed is learning media on smartphones with the Android operating system or commonly known as mobile learning.

The Android operating system is the most popular operating system in the world, the most dominant, and already familiar among high school students [6, 10, 13, 16]. The Android operating system has various features that are popular with teenagers such as various applications and games available that can be downloaded for free. But, the use of smartphones today is merely used as a means of entertainment without using it for more useful things, such as education. As we know it, smartphone technology has become a basic part of our lives, most teachers and students in all over the world [4]. The increasing demand for these cellular devices is a positive sign that these devices play an important role in our lives [13]. Users of the Android operating system are so large, including among teenage high school students, it makes an opportunity to develop Android-based learning media.

Learning media on Android devices becomes one of the new alternatives in learning that is interesting and fun [17]. This Android-based learning media has become the main target for advancing education because access to information is not limited by space and time [18]. Students can learn anytime and anywhere because their materials are in their hands [10]. By using a smartphone as learning media, it will provide deeper learning opportunities for students because, by using a smartphone, students can develop learning through information retrieval from the internet, and practice their skills [19]. Android-based learning media has advantages including: Easy to use and learning can be anywhere [6], learning offline [10], interactive and reducing the use of paper [18], learning independently and can be repeated [7], helping students to solve mathematical problems [20], fun and gain a better understanding [21]. Thus, the use of Android-based learning media as much as possible can be applied in all subjects, including mathematics.

Based on observations made in X-grade of Airlangga Health Vocational School of Balikpapan, it was found that students tended to be absorbed in learning activities themselves. The concentration of students in learning is easily influenced, so they prefer to do other things such as chatting with peers, sleepy, not excited, and look lazy. Teachers in the learning process are limited to using Microsoft PowerPoint, so the learning media in schools are less varied and make students unable to construct their own knowledge, so students easily feel bored in doing learning activities. This has an impact on the lack of students’ understanding of mathematics subjects, such as vector material [22]. Furthermore, according to the teacher, students have difficulty regarding the properties of vectors that are still abstract, the use of property and scalar multiplication operations of two vectors, determining the length of vectors in 3D objects, and low ability of students in problem solving.

One way to overcome the problems that occur is the need for learning media that can be used anytime and anywhere through student smartphones, or called mobile learning, for example through educational games. Nowadays, people are stimulated by the use of games for entertainment and play facilities which can be very time-consuming, especially for children who can spend hours. The educative and constructive aspects of the game are that individuals want to advance in the game and modify how to play [20]. This educational game can be very motivating while still maintaining or even increasing the effectiveness of student learning outcomes [23]. In addition, educational games will improve learning outcomes and student involvement [7, 23]. So, through the educational game that is used, students are expected to actively experience, understand the game, and solve the problems in it.

In connection with Android-based learning media, there are several studies that are in line, including research from Muyaroah & Fajartia [24] which results in the effectiveness of student learning outcomes using Android-based learning media on Biology subjects compared to using lecture methods because
learning media can be accessed anywhere and anytime. Research conducted by Lubis and Ikhsan [16] results that the Android-based Chemistry learning media developed has a positive influence on students’ motivation and cognitive achievement. Not only on Biology and Chemistry, other research is also conducted by Suprianto, Ahmadi, and Suminar [7] concluded that mathematics mobile learning can improve learning autonomous and learning outcomes of elementary students, and research conducted by Abdullah, & Yunianta [11] resulted that the mathematics educational game media on Trigonometry material helps students in learning Trigonometry because it has an attractive appearance, easy to understand, concise, easy to carry, and easy to access or play.

Based on the problems that have been described, researchers try to make Android-based learning media that can attract students’ enthusiasm to learn, so that students’ smartphones can be used optimally in the learning process. Therefore, the researchers hope that the making of Android-based learning media for mathematics subjects becomes an alternative or solution to the learning problems that occur. The name of the learning media developed is TORIQ (Vector Intelligence Quiz). The development of the TORIQ educational game certainly cannot be separated from the construction of several learning theories used, such as: a) behavioral theory, namely the use of the concept of stimulation, response, reinforcement factors, and feedback; b) cognitive psychology theory, which includes the use of students' memory, motivation, thoughts, and reflections; c) constructivism theory, that is, students actively find out and build knowledge to make understanding they understand; which means that the formation of concepts is built by students themselves through activities that stimulate bright ideas related to a concept, or in other words students themselves are responsible for learning events and learning outcomes [25, 26]. Thus, students have autonomy in learning so that they are responsible for organizing and disciplining themselves and in developing learning skills of their own volition [7].

2. Method
This research belongs to the category of research and development (R&D). The development method uses the Luther-Sutopo version of the Multimedia Development Life Cycle (MDLC) system. According to Luther [27], multimedia development methodology consists of six stages, namely: concept, design, material collecting, assembly, testing, and distribution. The data collection techniques are by:

- questionnaire; arranged according to the role and position of the data subject consisting of questionnaires for media experts, material experts, practitioners / teachers, and questionnaires for users (students);
- interview; conducted on Mathematics Teachers and X Grade Students of Airlangga Health Vocational School of Balikpapan;
- documentation study; to review some related literature, explore data in the form of notes, photographs and other data according to the focus of the study, as well as concrete steps in the implementation of TORIQ media development.

Based on the research and development stage used, the type of data obtained is quantitative and qualitative. Quantitative data in the form of scores obtained from the development product evaluation questionnaire for media experts, material experts, practitioners/teachers, and students compiled by Likert Scale. Furthermore, the quantitative data obtained are calculated using the percentage data analysis technique formulated as follows:

2.1. Validity data analysis techniques
The percentage formula of validity and practicality according to Rozak, Darmadi, & Murtafi‘ah [28]

\[
P = \frac{T_{sh}}{T_{se}} \times 100\%
\]

Note:

- \(P\) : Percentage of validity/practicality
- \(T_{sh}\) : Total expected score (total score scored by the validator/student)
- \(T_{se}\) : Total empirical score (maximum number of scores)
For validity, involving 5 validators including 2 media experts, 2 material experts, and 1 practitioner/teacher. So as to find out the overall percentage of the Alpha 1 or Alpha 2 Test, the researcher calculates the combined validity using the formula:

\[ P = \frac{P_1 + P_2 + P_3 + \ldots + P_{10}}{10} = \ldots \% \]  \hspace{1cm} (2)

The results of the analysis were further adjusted to the interpretation of the scores in Table 1.

### Table 1. Validity criteria of the developed media

| Percentage of validity (%) | Category             |
|----------------------------|----------------------|
| 80 ≤ P < 100               | Strongly valid       |
| 60 ≤ P < 80                | Valid                |
| 40 ≤ P < 60                | Simply valid         |
| 20 ≤ P < 40                | Less valid           |
| 0 ≤ P < 20                 | Invalid              |

2.2. Practically Data Analysis Techniques

To find out the percentage of practicality in the results of student questionnaires \( (P_{\text{student}}) \) and the practicality of practitioner / teacher \( (P_{\text{practitioner}}) \), questionnaires, Formula (1) is used. So to find out the overall percentage, the researcher made a combined calculation with the formula:

\[ P = \frac{P_{\text{student}} + P_{\text{practitioner}}}{2} = \ldots \% \]  \hspace{1cm} (3)

The results of the analysis were further adjusted to the interpretation of the scores in Table 2.

### Table 2. Practicality criteria of the developed media

| Percentage of practicality (%) | Category         |
|--------------------------------|------------------|
| 80 ≤ P < 100                   | Very practical   |
| 60 ≤ P < 80                    | Practical        |
| 40 ≤ P < 60                    | Simply practical |
| 20 ≤ P < 40                    | Less practical   |
| 0 ≤ P < 20                     | Not practical    |

2.3. Data analysis techniques for effectiveness

An analysis of the effectiveness of the TORIQ learning media is carried out on the results of students’ mathematics tests in achieving the specified learning outcomes level, or the Minimum Mastery Criteria (KKM) that have been set at school, which is 60. If 80% of 100% students reach 60 of the maximum score, then TORIQ learning media can be said to be effective [29].

3. Results and Discussion

3.1. Development Results

The use of the MDLC method produces research results with the following steps:

3.1.1. Concept. This stage produces the concepts. The development of the Android-based TORIQ learning media was developed based on the needs of teachers and students. The development of this media aims to make it easier for X Grade Students of Airlangga Health Vocational School of Balikpapan in studying vector. Vector material concepts that are displayed in the form of text and images as well.
Furthermore, the concept of TORIQ learning media content consists of basic competencies (KD), indicators, learning objectives, materials, quizzes, instructions and profiles.

3.1.2. *Design.* Researcher plans the material and makes a storyboard to illustrate the stages from one scene to another.

3.1.3. *Material collecting.* The results obtained at this stage are as follows: Learning materials, pictures, audio, and Adobe Flash Professional CS 6 with Actionscript 3.0.

3.1.4. *Assembly.* The results of making TORIQ learning media are as follows:

- Display of title and menu page (See Figure 1).

![Figure 1. Display of Title and Menu Page.](image1)

- Display of material and quiz page (See Figure 2).

![Figure 2. Display of material and quiz page.](image2)
3.1.5. Testing. The test was conducted to find out the Android-based TORIQ learning media in terms of validity, practicality, and effectiveness. The initial process in testing is to do the Alpha test. Alpha test is carried out in two stages to determine the feasibility of a learning media validated by 2 media experts, 2 material experts, and also 1 learning practitioner.

- **Alpha 1 Test and Alpha 2 Test**

| No. | Aspect | Alpha 1 Test | Alpha 2 Test |
|-----|--------|--------------|--------------|
|     |        | 1st Expert Score | 2nd Expert Score | 1st Expert Score | 2nd Expert Score |
| 1   | Audio (1, 2) | 5 | 10 | 8 | 10 |
| 2   | Software engineering (3, 4, 5, 6) | 16 | 17 | 19 | 19 |
| 3   | Visual (7, 8, 9, 10, 11, 12, 13) | 20 | 28 | 31 | 33 |
|     | Total | 41 | 55 | 58 | 62 |
|     | Percentage | 63,076% | 84,615% | 89,230% | 95,384% |
|     | Category | Valid | Strongly valid | Strongly valid | Strongly valid |

In general, based on Alpha 1 testing with Media Experts, TORIQ's shortcomings include aspects of back sound, design, and coloring that are still not interesting, and there are some buttons that don’t function properly. Therefore, TORIQ needs to be revised so that in Alpha 2 Test an increase in judgment is obtained by the Media Expert.

In addition, TORIQ was also validated by the Material Expert. Here are the results.

| No. | Aspek | Alpha 1 Test | Alpha 2 Test |
|-----|-------|--------------|--------------|
|     |        | 1st Expert Score | 2nd Expert Score | 1st Expert Score | 2nd Expert Score |
| 1   | Quality of contents (1, 2, 3, 4, 5, 6, 7, 8) | 31 | 35 | 37 | 36 |
| 2   | Quality of Quiz (9, 10, 11, 12, 13, 14) | 27 | 27 | 28 | 28 |
| 3   | Effects on learning strategies (15, 16, 17, 18, 19) | 20 | 21 | 22 | 23 |
|     | Total | 78 | 83 | 87 | 87 |
|     | Percentage | 82,105% | 87,368% | 91,578% | 91,578% |
|     | Category | Strongly valid | Strongly valid | Strongly valid | Strongly valid |

Based on the analysis of the material expert questionnaire in Alpha 1 test, it was suggested that the material presented in the TORIQ learning media was not yet fully able to foster student curiosity. This is because the material provided is still incomplete. So TORIQ needs to be revised and get a good rating when testing Alpha 2.

Finally, the TORIQ media was also validated by one learning practitioner expert. The following results are obtained.

| No. | Aspekt | Alpha 1 Test | Alpha 2 Test |
|-----|-------|--------------|--------------|
|     |        | Expert Score | Expert Score |
| 1   | Quality of contents (1, 2, 3, 4, 5, 6, 7, 8) | 40 | 40 |
| 2   | Quality of Quiz (9, 10, 11, 12, 13, 14) | 25 | 29 |
| 3   | Effects on learning strategies (15, 16, 17, 18) | 16 | 19 |
| 4   | Software engineering (19, 20, 21, 22, 23) | 20 | 23 |
|     | Total | 101 | 111 |
|     | Percentage | 87,826% | 96,521% |
|     | Category | Very practical | Very practical |
Based on the table above, both when testing Alpha 1 and Alpha 2, TORIQ learning media received a positive response. Practitioners only suggest that researchers can continue to innovate in the field of education, especially learning media.

Overall, from the results of the Alpha 1 test data analysis that has been presented, it can be seen that the overall assessment of the TORIQ learning media carried out by 5 experts is 80,998% (Strongly valid to be tested). Meanwhile, in the Alpha 2 test analysis that has been presented, it can be seen that the overall assessment of the TORIQ learning media carried out by 5 experts is 92,885% (Strongly valid to be tested). Thus, the average percentage of the validity of the TORIQ learning media from the Alpha 1 Test and the Alpha 2 Test is 86,928% (Strongly valid).

Furthermore, the experts will provide advice and recommendations if the media is deemed unfeasible for revision. After the revision, then Beta testing is done to see the practicality of the developed TORIQ learning media. Beta testing is done in two stages, namely the small group test and the large group test.

- **The Small Group Test**

At the time of testing, first the TORIQ learning media was installed on each student's cellphone. After that, the application is opened and students start playing it. Starting by pressing the click button, then students go to the main page that contains the menu Basic Competencies, Learning Indicators, Learning Objectives, Learning Materials, Quiz, Instructions, and Profiles. Students are not left alone, the teacher also controls and explains the Basic Competencies, Indicators, and Learning Objectives to be achieved. After that, students go to the Material menu which consists of Understanding Vector, Vector in R², and Vector in R³. After being allowed to study the material independently, students then head to the Quiz page. On the Quiz page, it contains 10 question entries and students are instructed to fill in the answers in the available column and check the correctness of the answers. At the end of the activity, students know the total score that they get. Learning can be completed and students are asked to exit the application by pressing the exit confirmation button.

After students learn to use the TORIQ learning media, then students fill out a questionnaire to find out their responses. Both small and large group testing, in general students give positive responses. The following results are presented in Table 6 and Table 7.

**Table 6. Assessment results in small group tests**

| No. | Aspect                              | Score of 10 students |
|-----|-------------------------------------|----------------------|
| 1   | Visual (1)                          | 44                   |
| 2   | Software engineering (7, 8)         | 82                   |
| 3   | Effects on learning strategies (4, 5, 6, 9) | 153                  |
| 4   | Quality of contents (2, 3, 10, 11, 12, 13, 14, 15) | 295                  |
|     | Total                               | 574                  |
|     | Percentage                          | 76,533%              |
|     | Category                            | Practical            |

Based on the small group test analysis data, it can be seen that the overall assessment of the TORIQ learning media by 10 students and learning practitioners in the Alpha 1 Test is 82,179% and is included in the very practical category for use in the process of learning activities.

- **The Large Group Test**

Based on the large group test analysis data that has been presented, it can be seen the overall assessment of the TORIQ learning media conducted by 30 students and learning practitioners in the Alpha 2 Test amounted to 88,238% and included in the category of very practical for use in the process...
of learning activities. Thus, the average percentage of practicality of TORIQ learning media from small and large group tests is 85.208% (Very practical), as seen in Table 7.

Table 7. Assessment results in large group tests

| No. | Aspect                                           | Score of 30 students |
|-----|--------------------------------------------------|----------------------|
| 1   | Visual (1)                                       | 127                  |
| 2   | Software engineering (7, 8)                      | 235                  |
| 3   | Effect on learning strategies (4, 5, 6, 9)       | 485                  |
| 4   | Quality of contents (2, 3, 10, 11, 12, 13, 14, 15) | 952                  |
|     | Total                                            | 1799                 |
|     | Percentage                                       | 79.955%              |
|     | Category                                         | Practical            |

As for the implementation of the learning achievement test to determine the effectiveness of the media developed, the test results showed that there were 28 students who reached KKM with a percentage of students’ completeness of 93.333%, so that the TORIQ learning media could be said to be effective. Table 8 shows the frequency distribution of students learning outcomes.

Table 8. Students’ learning outcomes

| Learning outcomes | Frequency |
|-------------------|-----------|
| 45 – 51           | 1         |
| 52 – 58           | 1         |
| 59 – 65           | 1         |
| 66 – 72           | 15        |
| 73 – 79           | 4         |
| 80 – 86           | 8         |

3.1.6. Distribution. Learning media is finished and will be saved in the form of .apk application file that will be inserted into a CD (Compact Disk). After that the CD containing the .apk file of the Android-based TORIQ learning media will be distributed to schools for use by teachers and students as they should.

3.2. Discussion
It should also be noted that at the time of the alpha test the researchers also saw that students were very enthusiastic in “learning while playing” using their respective smartphones. They are very interested, for example, when the sub-material or mission has been completed, they want to immediately complete the questions or Quiz exercises. Students repeat several times until the answer is correct. According to them, learning by using TORIQ is very useful, although on the one hand they sometimes ask about material that is not yet understood. For students, learning to use TORIQ must still be accompanied.
The teaching and learning process is essentially a communication process, namely the delivery of messages from sender to the receiver. Therefore, we need tools to deliver the message, namely learning media used by teachers to convey or distribute messages (subject matter) to students [26], as well as tools to stimulate students’ thoughts, feelings, concerns and interests in learning. The use of educational games as learning media can certainly arouse new desires and interests, generate motivation and stimulation of learning activities, help increase understanding, and present material in an interesting and reliable manner [30, 31]. Thus, by learning to use educational games, the time spent playing it will not be wasted [32]. Furthermore, [31] revealed that the position of game-based learning media is also a source of independent learning, which can not only be used as a learning aid, but can also be used by students with or without the subject teacher concerned.

Some research studies also show the positive impact of the use of educational games in learning, especially on mathematics. With the help of educational games, various mathematical phobias can be reduced and mathematics becomes more interesting [33], positive and fun attitudes and responses related to learning using computer games from students [26, 34], making students actively participate in solving problems and think critically about the problems contained in the game [20, 35], improve arithmetic abilities [36], provide flexibility for students to explore, focus commands on learning, concepts, and problem solving [37], effect on improving student academic performance high school and effective on student learning outcomes [7, 24, 38], motivating students [16, 39], indirectly students will learn with the routine without burdensome students in thinking [40], and so on. Thus, the use of games in the world of education is a necessity, which will provide a variety of positive impacts in the learning process.

Overall, according to the validators, the developed TORIQ learning media has several advantages.

4. Conclusion
Based on the results of research and development of Android-based TORIQ learning media, it can be concluded that the Android-based TORIQ learning media that have been developed are included in the category of Strongly valid with a percentage of 86,928%, Very practical with an average percentage of 85,208%; and Effective with a percentage of completeness of 93,333%. So that, overall the learning media TORIQ (Vector Intelligence Quiz) developed can be said to be feasible and can be an alternative media in learning activities, especially on Vector material.

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