Development of Android Based Instructional Media of Algebraic Tiles for Quadratic Equation

O F Irianti, A Qohar

Department of Mathematics, Faculty of Mathematics and Natural Sciences State University of Malang, Malang, East Java, Indonesia

orizafebriiirianti@gmail.com, abd.qohar.fmipa@um.ac.id

Abstract. This research and development aims to develop the android based instructional media of algebraic tiles for quadratic equation. The media created must meet the criteria of valid, practical, and effective to assist the student in understanding the factoring in quadratic equations. The research model used in this research is 4D model developed by Thiagarajan. This model is used and modified into 3 stages only, those are (1) define stage; (2) design stage; and (3) development stage. The resulting product is named FICTION (Factorization of Quadratic Equation) which has apk as it’s extension and can be deployed and installed on a minimum android-based smartphone on version 4.0 / 4.1 (Ice Cream Sandwich). After trials, it can be conclude that FICTION is valid with level of validity 3.83, practical with level of practicality 3.1, but ineffective because none of students could pass the score minimum criteria.

1. Introduction
Learning is the interaction of students with learning resources and teachers in a learning environment. Learning is done as an effort to empower students' potential towards the expected competencies. In the learning process, there is an interaction between teacher and student where the teacher submit information to students. This is in line with the opinion of [12], "In learning efforts occur communication between students and teachers. So that the learning process like this is as part of the communication process between people ". [4] also said that the teaching and learning process is essentially the process of communication, the delivery of messages from the deliver to the recipient.

Media is a tool or means or device that functions as an intermediary or channel or bridge in communication activities between communicators and communicants [12]. This is in line with opinion of [11] that said the purpose of media is to facilitated communication and learning. So, in the process of communication the media is needed to overcome differences in understanding between communicants and communicators. Media is also used in the learning process as one element that can facilitate teachers to deliver information to students [12]. In the learning process, the media used are refered to as instructional media. Learning that does not utilize the media, the message received by students is likely to be interpreted differently by each student, it is necessary to use the media to equate interpretation and conclude the intended message. This is in line with the opinion of [13] instructional media can clarify meaning so that it can be understood by students.

One of the materials taught in class IX of junior high school is quadratic equation. Quadratic equations are listed in Permendikbud No 24 of 2016 Appendix 15 concerning Core Competencies and Basic Competencies of Lessons in the 2013 Curriculum for Primary Education and Secondary
Education. KD 3.2 for class IX is written "Explaining the quadratic equation and its characteristics based on their roots and how to solve them". In general, quadratic equations contain variables and constants, where variables and constants themselves are abstract concepts for students [7]. The quadratic equation material contains abstract concepts for students. Therefore, learning the material of quadratic equations requires appropriate instructional media in order to make the concept that was originally abstract into concrete for students. [6] stated that for most students, quadratic equations are challenging because of its difficulties in algebraic procedures (particularly in factoring quadratic equation) and inability to apply meaning in quadratics.

Algebraic Tiles is one of the mathematics instructional media that is widely used in mathematics learning, especially algebra (see Figure 1). Algebraic tiles are square or rectangular which can represent algebraic expressions. (Core Connections, Course 1: 55).

![Algebraic Tiles](image)

**Figure 1.** Algebraic Tiles

Algebraic tiles instructional media can be used in learning various algebraic concepts, including (1) addition, subtraction and multiplication of algebra; (2) algebraic modeling and grouping of like terms; (3) the use of distributive properties; (4) solving linear equations using addition, subtraction, multiplication, or division; (5) solving linear equations containing 2 or more steps; (6) monomial multiplication with monomial, binomial with monomial, or binomial with binomial; (7) factoring quadratic equation or the difference of two squares; and (8) complete the quadratic equation [10]. Based on the usefulness of the algebraic tiles, it can be said that algebraic tiles can be used as instructional media for factoring quadratic equations.

According to the 2015 Ministry of Communication and Informatics data, it is estimated that Android smartphone users in Indonesia in 2018 will be more than 100 million people and Indonesia will occupy the fourth highest number of Android smartphone users in the world. This is certainly an opportunity for teachers to be able to create media that can be accessed on Android smartphones. The advantages of using an Android smartphone include (1) allowing use anywhere, (2) not requiring other additional tools, such as keyboards, (3) requiring simpler maintenance than computers or laptops [2]. Comparing to the earlier media, media that writers’ offered is focused only on factoring quadratic equation, so it consume less memory used. In addition, the application on the Android smartphone is easy to duplicate, and can also be run without the need for an internet connection.

With the background stated above, the author intends to conduct research and development of Android-based Instructional Media of Algebraic Tiles for Quadratic Equation

2. **Methods**

The research and development method chosen for the development of android-based instructional media of algebraic tiles for quadratic equation is the Four-D Model developed by [8]. The stages developed by Thiagarajan include 4 stages, namely (1) Define; (2) Design; (3) Develop; and (4) Disseminate. But in
this study will be done until the develop stage because of the limitation of time and cost. The define stage consist of some analysis such as front-end analysis, learner analysis, concept analysis, task analysis, and specifying instructional objectives. This stage aims to study, determine, and define learning needs. The design stage consist of constructing criteria-referenced test, media selection, format selection and initial design. This stage aims to design the media to be developed and the instruments needed. The develop stage consist of validation and trial.

The product trial design use an instrument in the form of a questionnaire and uses a Likert scale at intervals 1-4. The instruments made include: (1) Validation of Media, covering aspects of appearance and aspects of interaction; (2) Validation of Material, covering aspects of content and learning objectives and aspects of learning; (3) Validation of Student Response Questionnaires; and (4) Student Response Questionnaire. The validator appointed to test the validity of the media, material and student response questionnaire is Mr. Syaiful Hamzah Nasution, S.Si, M.Pd as a lecturer in Mathematics at Malang State University. Practical value and effectiveness were obtained from the assessment on student response questionnaires and student evaluation tests. The product trial subjects were 8 students randomly selected from class IX Sungsari 1 Junior High School, consisting of 2 high-ability students, 3 moderate-ability students, and 2 low-ability students.

Quantitative data from the validation results were analyzed using the average analysis technique from the modified [8] as follows:

Validity Test
Determine the average value of all validators for each indicator

\[ I_i = \frac{\sum_{j=1}^{n} V_{ji}}{n} \]

with \( V_{ji} \) is the value of the validator \( j \) to the indicator \( i \), and \( n \) is the number of validators.

Determine the validity score \( (V_a) \)

\[ V_a = \frac{\sum_{i=1}^{m} I_i}{m} \]

with \( I_i \) is the average value of the \( i \) and \( m \) is the number of indicators.

Practical Test
Determine the average value of all validators for each indicator

\[ I_i = \frac{\sum_{j=1}^{m} P_{ij}}{m} \]

with \( P_{ij} \) is the value of the respondent to \( j \) against the indicator to \( i \), \( m \) is the number of respondents.

Determine the practicality score \( (IO) \)

\[ IO = \frac{\sum_{i=1}^{n} I_i}{n} \]

with \( I_i \) is the average value of the indicator, \( i \) and \( m \) is the number of indicators.

Media development is said to be valid if the minimum value of the level of validity \( (V_a) \) is a valid level that is at intervals of \( 3 \leq V_a < 4 \). Validity criteria are presented in the Table 1 as follows:

| Interval | Validity Criteria |
|----------|-------------------|
| \( 1 \leq V_a < 2 \) | Invalid |
| \( 2 \leq V_a < 3 \) | Less Valid |
| \( 3 \leq V_a < 4 \) | Valid |
| \( V_a = 4 \) | Very Valid |
Media development is said to be practical if the minimum value is practicality (IO) is a high level that is at intervals $3 \leq IO < 4$. Practical criteria are presented in Table 2 as follows:

| Interval | Practical Criteria |
|----------|-------------------|
| $1 \leq IO < 2$ | Very Low |
| $2 \leq IO < 3$ | Low |
| $3 \leq IO < 4$ | High |
| $IO = 4$ | Very High |

Source: Adaptation and modification of ([8]: 53)

Media development is said to be effective if at least 75% of students get a score of 60 or higher on an evaluation test.

3. Result and Discussion

The result of developing of android-based instructional media of algebraic tiles is a file with an .apk extension that can be installed on an Android smartphone with a minimum specification in version 4.0 / 4.1 (Ice Cream Sandwich). The media developed is named FICTION, which stands for Factorization of Quadratic Equation. FICTION helps in explaining the factoring process of quadratic equations which have integer roots. In the process, FICTION uses a geometric approach, that is by using algebraic tiles as a tool to visualize a quadratic equation into a rectangular or rectangular flat. The length and width of the shape formed can visualize the factor of the quadratic equation. FICTION is created to help students understand the factoring of quadratic equations using a geometry approach. The display of FICTION media is as Figure 2 follows:

![Figure 2. Display of FICTION](image)

The way FICTION works is by dragging and dropping on the algebraic tiles located on the left in figure 2 and arranged in the white box on the right of the algebraic tiles. The algebraic tiles that are compiled must match the questions provided. For the example above, the algebra tiles needed are 1 algebra tile of $x^2$, 4 algebra tiles of $x$, and 3 algebra tiles of 1. The algebraic tiles must be arranged into a square or rectangular shape. Furthermore, the length and width of the shape formed into factor of the quadratic equation is asked. The factoring results are written in a white box under the box to arrange algebraic tiles.

Variable visualization of quadratic equations into algebraic tiles is an attempt to convert abstract objects into concrete objects. This is in line with the opinion of Edgar Dale (1946) in the Cone of Experience which states that the more concrete an instructional media is, the more information students can absorb becomes [5]. In addition, with students arranging algebraic tiles on their own so that become
rectangles or squares is one attempt to get students to experience learning directly so that information that can be absorbed by students becomes greater.

In its use, FICTION also actively involves students, where students actively arrange algebraic tiles according to the instructions provided. In addition, there have been the arrangement results that can help students when students meet some difficulties. This is in accordance with the constructivism theory which states that students are the main focus in learning and they build their own knowledge with their own initiative [9]. The use of FICTION in learning will make the teacher as a facilitator, where students become the main subject in learning. The way of teaching where teacher as a facilitator and the students become the main subject of learning is called student-centered [3]. Student-centered is the biggest contribution of constructivism so far [1].

FICTION has passed the validation stage before the trial. Validation includes media validation and material validation. After the trial was conducted, students also gave responses to student response questionnaires which later became practical values, besides that students also worked on the evaluation test section which later became the effectiveness value.

Data of validation, practicality, effectiveness will be presented in the following Table 3, Table 4, Table 5, Table 6 and Table 7.

**Table 3. Media Validation Data Analysis**

| Criteria | \( V \) |
|----------|---------|
| **Display Aspect** | |
| Media layout attracts attention | 4 |
| The use of letters / fonts (type, size and color) is appropriate | 4 |
| Text on media is easy to read | 4 |
| The combination of colors used is appropriate | 3 |
| Background does not interfere with content or content | 4 |
| The location of the navigation buttons is appropriate and consistent | 4 |
| Navigation buttons are functioning properly | 4 |
| **Interaction Aspect** | |
| Instructions for using learning media are clear | 4 |
| The media can be operated easily | 4 |
| Suitability of the button with its function | 4 |
| Users can easily move from one sub-material to another | 4 |
| Users can easily enter (input) answers on the media | 3 |
| **Total Score** | 46 |
| \( V_a \) | 3.83 |

Information:

- \( i \) : Indicators’ number
- \( V \) : Validator
- \( V_a \) : Average total value of all indicators

**Table 4. Media Validation Data Analysis**

| Criteria | \( V \) |
|----------|---------|
| **Aspects of Content and Purpose** | |
| The contents of the media are in accordance with the applicable curriculum | 4 |
| Media content is in accordance with core competencies, basic competencies and learning objectives | 4 |
| The contents of the media have a depth of concept that corresponds to the subject matter of the quadratic equation | 4 |

Information:
Based on the table above, the FICTION media is said to be "valid" because $V_a$ is worth 3.83. This means that the FICTION media is suitable for use in research.

**Table 5. Criteria of Student Response Quissionare Data**

| No | Criteria                                                                 |
|----|--------------------------------------------------------------------------|
| 1  | This media helps me when studying the material of quadratic equations    |
| 2  | This media makes me actively and independently involved in learning quadratic equations |
| 3  | This media motivates me to study quadratic material                      |
| 4  | This media is easy for me to operate                                     |
| 5  | Media is presented coherently from material that is easy to difficult material |
| 6  | The media is delivered clearly and is easy to understand                 |
| 7  | This media can be used as a learning resource for me                     |
| 8  | This media uses language that I understand easily                        |
| 9  | This media uses clear fonts (types, sizes and colors)                    |
| 10 | This media uses terms and symbols that I can easily understand           |
| 11 | The appearance of this media is interesting                              |

**Table 6. Data of Student Response Quissionare Data**

| No | $I_i$ | Score given by student number |
|----|-------|-------------------------------|
| 1  |       | 3 2 3 3 3 3 3 3 3           |
| 2  |       | 3 2 3 3 3 3 3 3 3           |
| 3  |       | 3 4 4 3 3 3 2 4 4           |
| 4  |       | 3 3 3 3 3 3 2 4 3           |
| 5  |       | 3 4 4 3 3 3 2 4 3           |
| 6  |       | 3 2 4 4 3 3 2 4 3           |
| 7  |       | 3 3 3 4 3 3 3 3 3           |
| 8  |       | 3 3 3 4 3 3 3 3 3           |
| 9  |       | 4 3 4 3 3 3 3 3 3           |
| 10 |       | 3 2 4 4 3 3 3 3 3           |
| 11 |       | 2 4 4 3 3 3 3 3 3           |

Total Score $34.14$

$V_a$ 3.83
Based on the table above, the FICTION media is said to be "practical" because the $IO$ is 3.1. This means that the FICTION media is suitable for use in learning.

| No | Student Name | Minimum Completeness Criteria | Score |
|----|--------------|-------------------------------|-------|
| 1  | AL           | 60                            | 20    |
| 2  | DFP          | 60                            | 10    |
| 3  | FA           | 60                            | 0     |
| 4  | JNK          | 60                            | 20    |
| 5  | MFAW         | 60                            | 20    |
| 6  | RZA          | 60                            | 20    |
| 7  | SYP          | 60                            | 20    |
| 8  | SDD          | 60                            | 30    |

$$E = \frac{x}{n} \times 100\%$$

Based on the table above, it is known that by using FICTION media, no student is able to get a score of 60 on the evaluation test. This means that the FICTION media is not effective in helping students understand the factoring of quadratic equations.

The ineffectiveness of FICTION in helping students understand quadratic equations can occur because of many factors. First, based on observations on student evaluation results, some students are able to work up to more than 6 out of 10 questions, but can only get 2 or 3 correct answers. However, if observed, there are many student errors found only in the plus or minus sign or it can be said that students are still confused about how to read the length and width of the shape formed from the arrangement of algebra tiles. Second, based on observations during the trial, students did not know algebraic tiles at all, so students found it difficult to form shapes that could be determined in length and width easily. If students already know algebraic tiles and use them in binomial multiplication, then it is likely that students can already determine the order that can be determined in length and width easily. Third, based on the observations during the trial, students did not understand the rules for the arrangement of algebraic tiles, where the tiles can only be side by side with tiles that have the same side size. For example, tile $x^2$ can only coexist with the $x$ tile, with the $x$-sized side attached to the tile $x^2$. Whereas, the $x$ tile can coexist with both the $x$ tile and the unit tile, with notes, the $x$ tile coexists with the $x$ tile each on the $x$-sized side, and the $x$ tile coexists with the respective unit tile on the side of the size 1. By chance, on FICTION, length x size equal to length 3 units. This indirectly makes students stuck composing 3 unit-sized tiles alongside $x$-sized tiles.

As an evaluation, if at the beginning students really do not know algebraic tiles, it is better to only use positive algebra tiles, to avoid students' mistakes in determining the operator or calculating the length and width of the formed side. In addition, for the next, developer should avoid the size of algebra tiles which are multiples of the others. This is so that students no longer experience errors in arrangement.
4. Conclusion

The results of development that have been validated and revised are android-based instruction media, namely FICTION. The results of product validation carried out by the validator obtained an average calculation of 3.83 whose meaning is valid. The results of the trial to 8 subjects showed an average value of practicality calculation of 3.1 which means the product was declared practical. The trial results also showed 0% of students were able to get a score of 60 or more on the evaluation test. This means that FICTION media is declared ineffective to help students understand factoring in quadratic equations. So it can be concluded that the FICTION media is valid and practical, but not effective.

Associated with the results of the study indicate that the media is not effective so it is not feasible to use in learning, therefore it is better not to use the media and disseminate it first. Some of the suggestions put forward by the author in the media development efforts are as follows:

- Researchers expect the development of the learning media of algebra tiles which then pay attention to the evaluations that have been submitted above.
- Researchers expect this learning media to be researched and revised further so that it can be used in learning

References

[1] Bada, D.R. and Steve, O. 2015. Constructivism Learning Theory: A Paradigm of Teaching and Learning IOSR Journal of Research and Method in Education 5(1) 36-47
www.iosrjournals.org.
[2] Carvalho, L. and Ferreira, M.J. 2015. Mobile Device in School in Teaching / Learning Process – The Roadmap. Proceedings of EDULEARN15 Conference Barcelona Spain 6th-8th July 2015.
[3] Collins, J.W. and O’Brien, N.P. 2011. The Greenwood Dictionary of Education 2nd Ed California ABC-CLIO, LLC.
[4] Daryanto, D. 2013. Media Pembelajaran Peranannya Sangat Penting Dalam Mencapai Tujuan Pembelajaran Yogyakarta Gava Media.
[5] Davis, B. S. 2015. Applying Dale’s Cone of Experience to Increase Learning and Retention: A Study of Student Learning in a Foundational Leadership Course, QScience Proceedings (Engineering Leaders Conference 2014) 2015:6 http://dx.doi.org/10.5339/qproc.2015 .ele2014.6
[6] Didis, M.G. and Erbas, A. K. 2015. Performance and Difficulties of Students in Formulating and Solving Quadratic Equation with One Unknown Educational Sciences Theory and Practice 15(4) 1157–1165.
[7] Hasratuddin. 2014. Pembelajaran Matematika Sekarang dan yang akan Datang Berbasis Karakter Jurnal Didaktik Matematika, 1(2), 30-42. ISSN: 2335-4185.
[8] Hobri. 2010. Metodologi Penelitian Pengembangan (Aplikasi pada Penelitian Pendidikan Matematika). Jember : Pena Salsabila.
[9] Jia, Q. 2010. A Brief Study on the Implication of Constructivism Teaching Theory on Classroom Teaching Reform in Basic Education. International Education Studies, 3(2), 197-199 www.ccsenet.org/ies.
[10] Leitze, A. R. and Kitt, N. A. 2000. Using homemade algebra tiles to develop algebra and prealgebra concepts Mathematics Teacher, 93(6), 462-467.
[11] Mantiri, F. 2014. Multimedia and Technology in Learning International Journal of Educationac Research 2(9), 589-592. DOI: 10.13189/ujer.2014.020901.
[12] Setyosari and Sihamudin. 2005. Media Pembelajaran. Malang: Elang Mas.
[13] Sudjana, N. 1997. Media Pengajaran. Bandung: Sinar Baru Algesindo.

Acknowledgments
My grateful acknowledgment to Mrs. Sunarti as teacher of Junior High School 1 Singosari, students’ that join on my research, my lecturer, my family, my friends and also DRPM Ristekdikti. Their support for this research and development was invaluable.