EduMa: Mathematics Education Learning And Teaching
July 2024, Vol 13 No 1 Page 10 – 23
https://syekhnurjati.ac.id/jurnal/index.php/eduma/eduma/article/view/xxxx
p-ISSN: 2086-3918, e-ISSN: 2502-5209
Published by Tadris Matematika IAIN Syekh Nurjati cirebon

EduMa
MATHEMATICS EDUCATION LEARNING AND TEACHING

Development of Web-Based Interactive Learning Media on Quadratic Equation Materials

M. Zainul Arifin[1*], Abd. Qohar[2]

[1,2] Department of Mathematics, Universitas Negeri Malang

*Corresponding author: Jl. Semarang 5, Kota Malang, Jawa Timur, 65145, Indonesia. e-mail addresses: zainularifin9195@gmail.com

a r t i c l e i n f o

How to cite this article:

Arifin, M. Z. & Qohar, A. (2024). Development of Web-Based Interactive Learning Media on Quadratic Equation Materials. Eduma : Mathematics Education Learning and Teaching, 13(1), 9 - 23.

doi: 10.24235/eduma.v13i1.14447

Article history:

Received: 07 10, 2023

Accepted: 07 25, 2024

Published: 07, 2024

a b s t r a c t

Web-based interactive learning media can help students in the learning process because of the easy access provided, one of which is by using Power Point and iSpring. The purpose of this research is to develop web-based interactive learning media containing quadratic equation material that is valid and practical so that it is useful for honing students' abilities in solving quadratic equation problems. The purpose of this research is to produce web-based interactive learning media that is suitable for the topic of quadratic equations, and uses a modified 4D development model consisting of three stages, namely determining objectives and strategies, designing products, and developing products. The data collected in this study were obtained through validation sheets and student questionnaires. After the validation process, peerteaching was carried out on several students. Based on the validity test results, the web-based interactive learning media on quadratic equation material has met the validity criteria. It is expected that this learning media can help students in learning quadratic equation material more interactively.

K e y w o r d s :
Learning media, Web-based, Ispring, Quadratic equation

INTRODUCTION

Technological advancements in education have led to the development of digital versions of previously printed textbooks, which can be accessed on computers or smartphones. These innovations have opened up new possibilities in the field of education (Purba et al., 2022a). According to Degner et al. (2022), digital media has a high potential to support the learning process. This media can present information in various forms, such as visual, auditive, or combine the virtual and real worlds. In addition, the adaptive and interactive features can match students' knowledge levels and provide a way for active learning. There has been a significant increase in the use of digital resources for education. This trend is driven in part by the demand for teaching materials that are not solely text-based, which has led to the growth of interactive learning media (Dewi et al., 2018).

Interactive media is software that combines images, videos, animations, sounds, and games so that users can interact directly (Kinasih & Hardiani, 2020; Novitasari, 2016). Educators must take advantage of the development of learning media optimally and wisely. Learning media is very important in the classroom. Learning media has two purposes, namely as a teaching aid and as a learning tool. (Degner et al., 2022).

APJII (Association of Indonesian Internet Service Providers) conducted a survey in the 2019-2020 period (Q2) which showed that around 73.7% of Indonesia's total population uses the internet. This is one indication that technological development in Indonesia is accelerating (*Asosiasi Penyelenggara Jasa Internet Indonesia*, 2016). Nevertheless, in 2020, researchers found the fact that teachers in several schools in Banjarmasin still rarely use the internet to create interactive learning media. Usually, teachers only use videos or PowerPoint as learning media. Web-based media is one part of the internet that uses the site as an interactive online learning resource that can improve the quality of education (Fitrahminarsih et al., 2021). One of the advantages of web-based learning media is that it is easily accessible, as students can access it through laptops, smartphones, or tablets by connecting to the internet.

Several researchers, such as Vaiyavutjamai & Clements (2006), have pointed out the lack of emphasis on quadratic equations in the literature on mathematics education. There is a scarcity of research on how quadratic equations are taught and learned. Only a few studies have delved into the methods students use to solve quadratic equations (Bossé & Nandakumar, 2005), students' comprehension of and struggles with solving quadratic equations (Kotsopoulos, 2007; Vaiyavutjamai & Ken Clements, 2006), the teaching and learning of quadratic equations in classrooms (Olteanu & Holmqvist, 2012; Olteanu & Olteanu, 2010), comparisons of how quadratic equations are addressed in math textbooks across different countries (Sağlam & Alacacı, 2012), and the integration of the history of quadratic equations in teacher training programs to assess prospective teachers' knowledge (Clark, 2012). Generally, quadratic equations pose challenges for most students due to difficulties in algebraic procedures, particularly in factoring them, and a struggle to attribute meaning to these mathematical concepts.

Understanding quadratic equations are the basis for further study in mathematics and other sciences (López et al., 2016a). However, It has been discovered through multiple studies that many high school and undergraduate students struggle to understand these equations or the methods used to solve them. Research conducted by López et al. (2016), Aygor & Burhanzade (2015), and Zakaria et al. (2010) showed that some errors in solving quadratic problems often occur due to a weak understanding of the concept. This implies that learning is needed that support students' understanding of the concept of solving quadratic equations. Therefore, using this web-based interactive learning media is expected to help students in learning quadratic equations so that their understanding of this material can be improved.

Developing web-based interactive learning media for the topic of quadratic equations is crucial due to its significance in various fields like science, engineering, and mathematics. Quadratic equations are fundamental in modeling natural phenomena, such as the path of projectiles or the design of parabolic antennas (López et al., 2016b). The interactive nature of web-based learning tools can enhance students' understanding by visualizing complex concepts like parabolas and quadratic functions (Purba et al., 2022b). The urgency to create such interactive tools is evident in the diverse methods used to solve quadratic equations, including factoring, completing the square, and using the quadratic formula. These methods can be challenging for students to grasp through traditional teaching methods alone. Interactive media can provide a dynamic platform for students to engage with these concepts, making learning more accessible and engaging. Furthermore, the versatility of quadratic equations in real-world applications underscores the need for effective educational resources. By offering interactive simulations and visualizations, web-based tools can bridge the gap between theoretical knowledge and practical application, preparing students for real-world problem-solving (Arifin et al., 2023; Pujiastuti et al., 2020; Sumarwati et al., 2020).

In conclusion, the development of web-based interactive learning media for quadratic equations is essential to facilitate a deeper understanding of this foundational mathematical concept and its wide-ranging applications across various disciplines. Such tools can enhance student engagement, comprehension, and retention by providing an immersive learning experience that complements traditional teaching methods. This development research aims to develop such learning media that is in accordance with the needs of grade IX students so that it can help students in practicing the skills of solving quadratic equation problems. The learning media developed must meet valid and practical criteria

METHODS

This research is development research (Research and Development) that uses the 4D model proposed by Thiagarajan (Thiagarajan et al., 1974). The 4D model proposed by Thiagarajan consists of four main stages: Define, Design, Develop, and Disseminate. This model is commonly used in research and development processes, particularly in the development of learning media. The first stage, the Define stage, involves defining the development requirements through needs analysis and collecting information on the extent of development needed. This stage includes activities such as studying supporting literature, research design, data collection techniques, and data analysis methods. The

second stage is the Design stage, which includes steps like constructing criterion-referenced tests, selecting media, choosing formats, and initial design (Hariyanto et al., 2022). The third stage is the Develop stage, where actual development trials are conducted to create the learning tools or solutions (Hariyanto et al., 2022). Finally, the Disseminate stage focuses on sharing the developed tools or solutions with users through strategies like user analysis, timing of dissemination, and selection of dissemination media (Hariyanto et al., 2022).

Thiagarajan's 4D model provides a structured approach to research and development processes, ensuring a systematic progression from defining needs to disseminating solutions effectively. However, in this study, these stages were adjusted to the situation and conditions. The development stage only reached the development stage, namely expert assessment, and limited trials through peer-teaching in the class B learning media course of the master of mathematics education program at the State University of Malang class of 2021. Dissemination to other schools was not carried out due to researcher limitations.

To develop this media, qualitative data in the form of criticism and suggestions from validators and quantitative data in the form of scores obtained from validation sheets filled out by validators and student questionnaires are used. All of these data are used to revise and evaluate the quality of the learning media developed, to produce learning media that meet valid criteria. In this development research, data analysis was carried out by calculating all the average values obtained from the validation sheet according to the steps (Hobri, 2010), and to determine the validity used the validity criteria in Table 1 below.

Data analysis techniques in this development research were carried out with the following steps (Hobri, 2010).

(1) Recapitulate the validity assessment data of learning media in a table that includes aspects (A_i), indicators (I_i), and values (V_i) for each validator.
(2) Calculating the average score of all validators for each aspect of the assessment. The formula used to find the average with the following formula.

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

Description:
I_i is the average validation result
V_{ji} is the validator's score data on the i-th indicator
n is the number of validators

(3) Determine the average score for each aspect with the following formula.

$$A_i = \frac{\sum_{j=1}^{n} I_{ji}}{m}$$

Description:
A_i is the average for the i-th aspect
I_{ji} is the average of the i-th aspect of the j-th indicator
m is the number of indicators in the i-th aspect

(4) Determine the value (V_a) or the total average value of all aspects using the following formula.

$$V_a = \frac{\sum_{i=1}^{n} A_i}{n}$$

Description:

V_a is the average score for all aspects
I_{ji} is the average for the i-th aspect
n is the number of aspects

To determine the validity criteria based on the V_a value or the average value for all aspects, Table 1 is used below.

Table 1. Criteria of Validity

Total Average for All Aspects	Criteria
$25\% \leq V_a < 50\%$	Not valid
$50\% \leq V_a < 75\%$	Less Valid
$75\% \leq V_a < 100\%$	Valid
$V_a = 100\%$	Highly valid

RESULT AND DISCUSSION

The final result of this development research is a web-based interactive learning media on quadratic equation material. This research uses a modified 4D development model with the following stages.

Define

At this stage, initial observations were made to find out what kind of media the teacher used and the obstacles with the media. Teachers still use media that is limited to video-based media sourced from YouTube, which are still few videos that can help students understand a concept intuitively. In video-based learning media, students cannot give input and then get feedback from the learning media, so they are limited to what is conveyed in the video. Based on these problems, it was decided to create a learning media on quadratic equation material where students can give input and then get feedback, one of which is by using iSpring software.

Design

This stage is carried out to produce a draft of learning media. Activities at this stage are

(1) Test Preparation

The test is based on the competency criteria that must be achieved in accordance with the specific learning objectives, where through the test questions students must be able to determine the roots of quadratic equations using the factoring method correctly.

(2) Media selection

The selection of media using iSpring because it can add Quiz features and produce output in the form of a web that can be accessed easily by students and with various devices as long as they are connected to the internet. This kind of thing cannot be obtained on learning media using other software.

(3) Format selection

The online learning media developed by contains the Home menu, Instructions, Basic Competence (KD) and Indicators of Competence Achievement (IPK), Materials, Exercises, and About.

(4) Initial media design

At this stage, the PowerPoint design that will be used in the learning media begins to be made, and looking for some of the images needed, the images displayed are images related to the daily lives of students, so that they feel more involved and interested in the material being taught. The following is the initial appearance of the learning media presented in Figure 1 and Figure 2 below.

Figure 1. The initial display of learning media

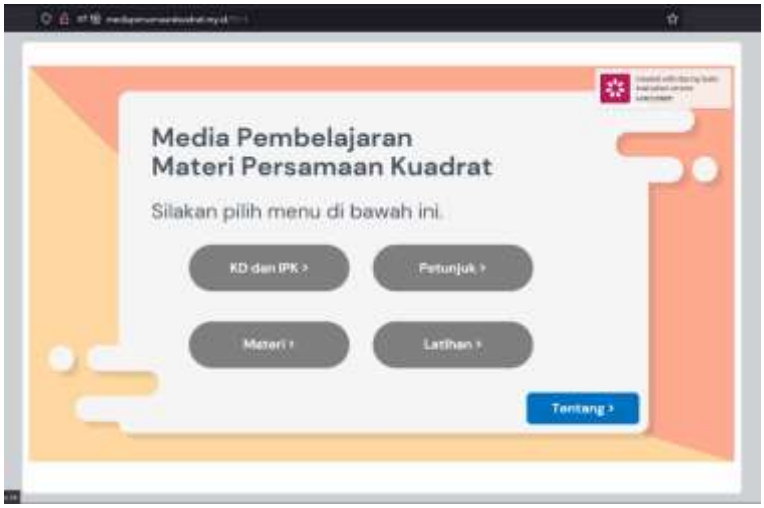

Figure 2. Home display of learning media

Then at this design stage, research instruments were also prepared in the form of validation sheets and student questionnaires.

Develop

This media draft was then submitted to three validators, namely 2 Master of Mathematics Education students and 1 UM Mathematics Education Lecturer. The validation results are presented in Table 2 and Table 3 as follows.

Table 2.
Validation Result

Aspect	Average Score
Learning Media Content	3,23
Images and animations	2,91
Usability of Learning Media	3,55
Language and symbols	3,33
Average	3,25

Table 3.
Student Questionnaire Results

Aspect	Average Score
Presentation of Material	3,52
Language and Display	3,62
Average	3,57

Through the development process, an interactive media namely "Quadratic Equation Media" has been produced. This media contains a menu of materials, practice questions, and competency tests on quadratic equation material, namely determining the roots of a quadratic equation by factoring. The material is presented through PowerPoint slides that are uploaded to the website to make it easier for students to access the material. Because using web-based interactive media can provide a positive response to the learning material presented and become an effective learning resource in improving learning performance (Handayani & Rahayu, 2020).

Quadratic Equation Media uses the internet to provide slides that can be accessed online. This media consists of five main pages, namely "KD dan IPK", "Petunjuk", "Materi", "Latihan", and "Tentang". The "KD dan IPK" page presents the basic competencies and indicators contained in the media. The basic competencies presented are in accordance with the 2013 curriculum for the chapter of quadratic equations in class IX which gives an idea of what material will be learned using the Quadratic Equation media (Fatoni et al., 2017).

The "Petunjuk" page contains instructions that can facilitate students in operating the learning media. On the 'Material' page, students first select the section they want to learn. These sections are Introduction, Factoring, Example 1, Example 2, and Quiz. In the introduction section, students are given illustrations of various things in daily life related to quadratic equations, namely the activity of throwing a ball into a basketball hoop, an angry birds game, and a fountain. Therefore, students will understand quadratic equations more intuitively. Giving examples from everyday life can make learning more

meaningful for students and make them appreciate the knowledge to be learned more (Retnodari et al., 2020)

Next, students are instructed to go to the factoring section. It is in this section that students begin to try to discover the concept of finding the roots of a quadratic equation using the factoring method. Starting with the process of observing examples of quadratic equations, students then try to arrange the roots. Finally, students can discover the concept of translation in mathematics. The activity of finding the concept of determining the roots of a quadratic equation by factoring method is done by students by constructing their own understanding through the use of this learning media because it is in line with the concept of translation in mathematics.

After discovering the concept of determining the roots of a quadratic equation by factoring, several problems about quadratic equations are given in the "Contoh 1" and "Contoh 2" sections. By solving these problems, students will be able to apply the concept of factoring that they have just learned to the quadratic equation material that they have learned before. This will train students' ability to connect materials in mathematics and make the use of learning media more meaningful (Abidin, 2020). Students together with the teacher discuss the problem. Students express their opinions and other students respond then the teacher is in charge of straightening back if something is not in accordance with the learning material.

After completing all activities on the Introduction, Factoring, Example 1, and Example 2 pages, students can then try the Quiz. A quiz is given to each submitter. Giving Quizzes aims to attract students' attention to make it easier to learn the material given (Ardiansyah, 2020). The form of questions in Quiz questions is in the form of multiple choice and short form. Each question is also equipped with the correct answer after the student answers the question. Next, students go to the 'Exercise' page to test their understanding of the whole material on determining the roots of quadratic equations by factoring.

The validation results show that the media is quite valid in general, with an average score of 3.23. The validator stated that the material contained in the media is very suitable and the media can support student learning activities in quadratic equation material. However, the validator also suggested improving the media display to make it more attractive. Media trials on students generally scored 3.54, so the media can be used with minor revisions. Students who tried the media found the media interesting, easy to operate, and able to motivate in learning mathematics. However, they also suggested that some of the back buttons that did not work be fixed, and the display of the questions be changed to make it easier for students to answer them. This is important because interactive media must provide convenience for users in accessing it (Fatoni et al., 2017).

Quadratic Equation Media can be accessed by students independently and used either in class or outside of class. This is in accordance with Mayer (2020) which shows that portable learning media has the potential to support academic learning anywhere and anytime, and allows students to learn little by little when there is time available. The results of this study also support several other studies that use iSpring-assisted learning media, such as the research of Cahyanti et al. (2019), and Ramadhani et al. (2019), which show that the

developed media are effective in improving student learning achievement, especially in developing their mathematical abilities.

iSpring offers excellence in math learning by providing an interactive and multimedia platform, allowing users to integrate various types of media as well as dynamic content such as animations and simulations (Aldowah et al., 2019). In addition, iSpring also facilitates the creation of interactive quizzes and exams, making it easier for teachers to evaluate student progress in real-time. With easy sharing of materials and progress monitoring features, iSpring provides flexibility in teaching and learning math across multiple platforms and devices (Nurwijayanti et al., 2019). Although learning media using iSpring has many advantages, it also has limitations, that is, limitations in creating very complex content. While iSpring provides a wide range of multimedia features, for highly technical or interactivity-intensive math materials such as complex simulations, iSpring may not have the same flexibility or capabilities as specialized math simulation software. Also, depending on the version and package used, some advanced features may cost extra or not be available in the standard package. This can be an obstacle for users on a budget who need these features to support deeper and more interactive math learning (Nurwijayanti et al., 2018).

The study's findings support the notion that media planning for learning should be tailored to students' needs and promote two-way interaction by incorporating teachers' diverse qualities (Yuberti et al., 2021). The results indicate that using android-based mathematics learning media with iSpring assistance enhances students' mathematical problem-solving abilities. The media has combined various elements, such as images and text, to make learning mathematics more relaxed, which can enhance students' experience, understanding, interest, and attention to the material (Chang et al., 2017).

The results indicate that this approach can stimulate and optimize students' mathematical problem-solving skills. These findings are consistent with previous research on Android-based learning media, which has been shown to improve problem-solving skills (Fatma & Partana, 2019). The development of android-based mathematics learning media should continue to consider the rapid advancement of science and technology (IPTEK), particularly in the current Covid-19 pandemic situation where all teaching and learning activities are conducted online from home. This learning media helps to prevent monotony in the delivery of material and keeps up with the times (Mahuda et al., 2021).

This web-based learning media, assisted by iSpring, can be easily developed by teachers or lecturers without requiring complicated programming languages. It allows students to learn anytime and anywhere using their smartphones, PCs, or laptops (Yani et al., 2020). Additionally, given the high usage of smartphones among adolescents and students, this media provides a convenient alternative to conventional textbooks for finding lecture references. The development of iSpring-assisted web-based learning media enables students to learn by simply opening their smartphones, without the need to search for references in conventional textbooks (Nurwijayanti et al., 2019).

The study, similar to others, has constraints. It did not account for factors like peer interaction, communication skills, and the broader acceptance of using media on various topics, which could enhance spatial abilities (Apriliani et al., 2020). These limitations

create opportunities for further research on presenting mathematical topics through media and educational tools.

CONCLUSION

The results of the development that have been validated and revised are web-based interactive learning media. The results of product validation conducted by validators obtained an average calculation of 3.23 which is included in the valid category. The results of the trial (peer-teaching) of mathematics education master students offering B showed an average value of practicality calculation of 3.54 which means that the product is declared practical.

The results showed that the media was valid and practical, but did not know its effectiveness. Therefore, the media should not be used and disseminated first. Some suggestions put forward by researchers in media development efforts are as follows: (1) Researchers hope that the development of this quadratic learning media can be tested on students to determine its effectiveness. (2) Researchers hope that this learning media can be developed on a broader quadratic equation material not only limited to the factoring method.

ACKNOWLEDGMENTS

The researcher would like to thank the mathematics education students of offering B class of 2021 who have helped researchers conduct research and who have allowed researchers to make observations for research purposes, and to Dr. Abd. Qohar, M.T. as the lecturer of the Learning Media course who has guided researchers in compiling this article

REFERENCES

Abidin, Z. (2020). Efektivitas Pembelajaran Berbasis Masalah, Pembelajaran Berbasis Proyek Literasi, Dan Pembelajaran Inkuiri Dalam Meningkatkan Kemampuan Koneksi Matematis. *Profesi Pendidikan Dasar*, *7*(1), 37–52. https://doi.org/10.23917/ppd.v7i1.10736

Aldowah, H., Ghazal, S., Umar, I. N., Amali, L. N., Kadir, N. T., & Latief, M. (2019). Development of e-learning content with H5P and iSpring features. *Journal of Physics: Conference Series*, *1387*(1), 012019. https://doi.org/10.1088/1742-6596/1387/1/012019

Apriliani, L. R., Irham, M., Latifah Darojat, dan, Jateng di Semarang, S. N., Paracendekia Sumbawa, S. N., & Al Islam Surakarta Corresponding Author, S. (2020). Pengembangan Media dan Bahan Ajar Interaktif "Scan It" Berbasis Geogebra. *Kreano, Jurnal Matematika Kreatif-Inovatif*, *11*(2), 213–222. https://doi.org/10.15294/KREANO.V11I2.26909

Ardiansyah, M. (2020). Pemanfaatan Aplikasi KAHOOT! Sebagai Media Pembelajaran Matematika Kreatif. *JUMLAHKU: Jurnal Matematika Ilmiah*, *6*(2), 145–155. https://doi.org/https://doi.org/10.33222/jumlahku.v6i2.1136

Arifin, M. Z., Danaryanti, A., & Suryaningsih, Y. (2023). Development of Online Learning Media Using Geogebra and LaTeX on Derivative Material. *Indonesian Journal of*

Science and Mathematics Education, *6*(1), 59–72. https://doi.org/10.24042/ijsme.v6i1.15367

Asosiasi Penyelenggara Jasa Internet Indonesia. (2016). https://apjii.or.id/survei/surveiinternetapjii20192020q2-21072046

Aygor, N., & Burhanzade, H. (2015). Students' Performances in Solving 2nd Degree Equations with One Unknown. *Procedia - Social and Behavioral Sciences*, *197*(February), 13–18. https://doi.org/10.1016/j.sbspro.2015.07.040

Bossé, M. J., & Nandakumar, N. R. (2005). The factorability of quadratics: motivation for more techniques. *Teaching Mathematics and Its Applications: An International Journal of the IMA*, *24*(4), 143–153. https://doi.org/10.1093/TEAMAT/HRH018

Cahyanti, A. D., Farida, F., & Rakhmawati, R. (2019). Pengembangan Alat Evaluasi Berupa Tes Online/Offline Matematika dengan Ispring Suite 8. *Indonesian Journal of Science and Mathematics Education*, *2*(3), 363–371. https://doi.org/10.24042/ijsme.v2i3.4362

Chang, C. C., Liang, C., Chou, P. N., & Lin, G. Y. (2017). Is game-based learning better in flow experience and various types of cognitive load than non-game-based learning? Perspective from multimedia and media richness. *Computers in Human Behavior*, *71*, 218–227. https://doi.org/10.1016/J.CHB.2017.01.031

Clark, K. M. (2012). History of mathematics: Illuminating understanding of school mathematics concepts for prospective mathematics teachers. *Educational Studies in Mathematics*, *81*(1), 67–84. https://doi.org/10.1007/S10649-011-9361-Y/METRICS

Degner, M., Moser, S., & Lewalter, D. (2022). Digital media in institutional informal learning places: A systematic literature review. *Computers and Education Open*, *3*, 100068. https://doi.org/10.1016/j.caeo.2021.100068

Dewi, R., Ilma, R., Putri, I., & Hartono, Y. (2018). Pengembangan Multimedia Interaktif Berbasis PMRI Materi Jajargenjang. *Kreano, Jurnal Matematika Kreatif-Inovatif*, *9*(1), 78–83. https://doi.org/10.15294/KREANO.V9I1.14367

Fatma, A. D., & Partana, C. F. (2019). Pengaruh penggunaan media pembelajaran berbasis android terhadap kemampuan pemecahan masalah kimia. *Jurnal Inovasi Pendidikan IPA*, *5*(2), 229–236. https://doi.org/10.21831/JIPI.V5I2.26035

Fatoni, M. faizal, Dafik, & Fatahillah, A. (2017). Pengembangan Media Pembelajaran Interaktif Online Menggunakan KelasKita Berbantuan Software Geogebra pada Materi Persamaan Kuadrat. *Kadikma : Jurnal Matematika Dan Pendidikan Matematika*, *8*(2), 24–33. https://doi.org/https://doi.org/10.19184/kdma.v8i2.6070

Fitrahminarsih, N. F., Syarif, S., Ahmad, M., Budu, & B, Y. S. (2021). Web-based learning media the skills of suturing rupture perineum of midwifery students. *Gaceta Sanitaria*, *35*, S248–S250. https://doi.org/10.1016/j.gaceta.2021.07.017

Handayani, D., & Rahayu, D. V. (2020). Pengembangan Media Pembelajaran Interaktif Berbasis Android Menggunakan Ispring Dan Apk Builder Untuk Pembelajaran Matematika Kelas X Materi Proyeksi Vektor. *M A T H L I N E Jurnal Matematika Dan Pendidikan Matematika*, *5*(1), 12–25. https://doi.org/10.31943/mathline.v5i1.126

Hariyanto, B., MZ, I., SU, W., & Rindawati. (2022). 4D Model Learning Device Development Method of the Physical Geography Field Work Guidance Book. *MATEC Web of Conferences*, *05008*(372), 14. https://doi.org/10.1051/matecconf/202237205008

Hobri. (2010). *Metodologi Penelitian Pengembangan*. Pena Salsabila.

Kinasih, I. P., & Hardiani, N. (2020). Role Playing and the Changing of Teacher Understanding to Middle School Mathematics Lesson Planning within ELPSA Framework. *Jurnal Pendidikan Matematika*, *14*(2), 183–198. https://doi.org/10.22342/jpm.14.2.6647.183-198

Kotsopoulos, D. (2007). Unravelling Student Challenges with Quadratics: A Cognitive Approach. *The Australian Mathematics Teacher*, *63*(2), 19–24. https://search.informit.org/doi/10.3316/informit.135995778236633

López, J., Robles, I., & Martínez-Planell, R. (2016a). Students' understanding of quadratic equations. *International Journal of Mathematical Education in Science and Technology*, *47*(4), 552–572. https://doi.org/10.1080/0020739X.2015.1119895

López, J., Robles, I., & Martínez-Planell, R. (2016b). Students' understanding of quadratic equations. *International Journal of Mathematical Education in Science and Technology*, *47*(4), 552–572. https://doi.org/10.1080/0020739X.2015.1119895

Mahuda, I., Meilisa, R., & Nasrullah, A. (2021). Pengembangan Media Pembelajaran Matematika Berbasis Android Berbantuan Smart Apps Creator Dalam Meningkatkan Kemampuan Pemecahan Masalah. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *10*(3), 1745. https://doi.org/10.24127/ajpm.v10i3.3912

Mayer, R. E. (2020). Where is the learning in mobile technologies for learning? *Contemporary Educational Psychology*, *60*, 101824. https://doi.org/10.1016/j.cedpsych.2019.101824

Novitasari, D. (2016). Pengaruh Penggunaan Multimedia Interaktif Terhadap Kemampuan Pemahaman Konsep Matematis Siswa. *FIBONACCI: Jurnal Pendidikan Matematika Dan Matematika*, *2*(2), 8. https://doi.org/10.24853/fbc.2.2.8-18

Nurwijayanti, A., Budiyono, B., & Fitriana, L. (2018). The Use of Interactive Media Ispring Suite 8 Supported by Google SketchUp to Improve Students' Geometry Skills Based on Hoffer's Theory. *Journal of Physics: Conference Series*, *1008*(1), 012075. https://doi.org/10.1088/1742-6596/1008/1/012075

Nurwijayanti, A., Budiyono, & Fitriana, L. (2019). COMBINING GOOGLE SKETCHUP AND ISPRING SUITE 8: A BREAKTHROUGH TO DEVELOP GEOMETRY LEARNING MEDIA. *Journal on Mathematics Education*, *10*(1), 103–116. https://doi.org/10.22342/JME.10.1.5380.103-116

Olteanu, C., & Holmqvist, M. (2012). Differences in success in solving second-degree equations due to differences in classroom instruction. *International Journal of Mathematical Education in Science and Technology*, *43*(5), 575–587. https://doi.org/10.1080/0020739X.2011.622807

Olteanu, C., & Olteanu, L. (2010). To change teaching practice and students' learning of mathematics. *Education Inquiry*, *1*(4), 381–397. https://doi.org/10.3402/EDUI.V1I4.21952

Pujiastuti, H., Utami, R. R., & Haryadi, R. (2020). The development of interactive mathematics learning media based on local wisdom and 21st century skills: social arithmetic concept. *Journal of Physics: Conference Series*, *1521*(3), 032019. https://doi.org/10.1088/1742-6596/1521/3/032019

Purba, H. S., Sukmawati, A., Wiranda, N., Suryaningsih, Y., & Aprilian, R. (2022a). Developing Wetland Contextual Interactive Learning Media on Numbers Using Drill and Practice Method. *Jurnal Pendidikan Matematika*, *16*(1), 45–56. https://doi.org/https://doi.org/10.22342/jpm.16.1.14153.45-56

Purba, H. S., Sukmawati, A., Wiranda, N., Suryaningsih, Y., & Aprilian, R. (2022b). Developing Wetland Contextual Interactive Learning Media on Numbers Using Drill and Practice Method. *Jurnal Pendidikan Matematika*, *16*(1), 45–56. https://doi.org/10.22342/JPM.16.1.14153.45-56

Ramadhani, D., Fatmawati, E., & Oktarika, D. (2019). Pelatihan Pembuatan Media Evaluasi dengan Menggunakan Ispring di SMA Wisuda Kota Pontianak. *GERVASI: Jurnal Pengabdian Kepada Masyarakat*, *3*(1), 24. https://doi.org/10.31571/gervasi.v3i1.1194

Retnodari, W., Elbas, W. F., & Loviana, S. (2020). Scaffolding dalam Pembelajaran Matematika. *LINEAR: Journal of Mathematics Education*, *1*(1), 19–27. https://doi.org/10.33654/math.v1i1.93

Sağlam, R., & Alacacı, C. (2012). A Comparative Analysis of Quadratics Unit in Singaporean, Turkish and IBDP Mathematics Textbooks. *Turkish Journal of Computer and Mathematics Education (TURCOMAT)*, *3*(3), 131–147. https://turcomat.org/index.php/turkbilmat/article/view/43

Sumarwati, S., Fitriyani, H., Setiaji, F. M. A., Amiruddin, M. H., & Jalil, S. A. (2020). Developing Mathematics Learning Media Based on E-Learning using Moodle on Geometry Subject to Improve Students' Higher Order Thinking Skills. *International Journal of Interactive Mobile Technologies (IJIM)*, *14*(04), 182–191. https://doi.org/10.3991/IJIM.V14I04.12731

Thiagarajan, S., Semmel, D. S., & Semmel, M. I. (1974). *Instructional Development for Training Teachers of Exceptional Children: A Sourcebook*. Council for Exceptional Children.

Vaiyavutjamai, P., & Ken Clements, M. A. (2006). Effects of classroom instruction on students' understanding of quadratic equations. *Mathematics Education Research Journal*, *18*(1), 47–77. https://doi.org/10.1007/BF03217429/METRICS

Yani, M., Yani, M., Shahril, S., Putra, R. W. Y., & Simatupang, A. T. (2020). Sparkol Learning Media: Is it Effective to Improve Students' Mathematical Understanding? *Indonesian Journal of Science and Mathematics Education*, *3*(3), 329–335. https://doi.org/10.24042/ijsme.v3i3.5240

Yuberti, Y., Wardhani, D. K., & Latifah, S. (2021). Pengembangan Mobile Learning Berbasis Smart Apps Creator Sebagai Media Pembelajaran Fisika. *Physics and Science Education Journal (PSEJ)*, 90–95. https://doi.org/10.30631/PSEJ.V1I2.746

Zakaria, E., Ibrahim, & Maat, S. M. (2010). Analysis of Students' Error in Learning of Quadratic Equations. *International Education Studies*, *3*(3), 105–110. https://doi.org/10.5539/ies.v3n3p105