Development of algebraic domino games in mathematics learning based on ICT in junior high school

U Umbara¹,²*, Munir³, R Susilana⁴ and E F W Puadi¹

¹Department of Mathematics Education, STKIP Muhammadiyah Kuningan, Jl. Moertasiah Supomo No. 28B, Kuningan 45511, Indonesia
²School of Postgraduate, Indonesia University of Education, Jl. Dr. Setia Budi No. 229, Bandung 40154, Indonesia
³Department of Computer Science, Universitas Pendidikan Indonesia, Jl. Dr. Setia Budi No. 229, Bandung 40154, Indonesia
⁴Department of Educational Technology, Universitas Pendidikan Indonesia, Jl. Dr. Setia Budi No. 229, Bandung 40154, Indonesia

*uba.bara@upmk.ac.id

Abstract. The development of ICT in learning mathematics is one of the innovative efforts that can be used as an alternative to the development of mathematical learning models. Based on these arguments, the aim of this research is to develop ICT learning tools based on interactive mathematical games in junior high schools called domino algebra. This research is a research development of multimedia prototypes based on interactive mathematical games. The results of the development show the average value of the media expert validation test was 4.62, while the average value of the content content expert validation was 4.81. The practicality test results of the usage by the teacher get a value of 4.72 while the average practicality test results by students are one to one try out evaluations, small group evaluations, and field evaluations with a total of 20 students getting an average value of 4.63. Based on these data, ICT learning based on interactive mathematical games developed is declared suitable for use in mathematics learning in junior high schools.

1. Introduction

The development of instructional media, whatever its form, is one of the efforts made by teachers to improve or improve the quality of mathematics learning. The use of media in learning has the main function as a communication tool. As a communication tool between teachers and students, the use of instructional media can increase the effectiveness and achievement of learning goals to the maximum [1]. In general, instructional media can be classified into two types, namely conventional media and multimedia learning. Conventional media or more often mentioned as learning media is media that was developed with simple tools, while learning multimedia is developed with computer devices. Multimedia is developed and delivered through the use of computer devices or other compatible equipment, with a combination of media consisting of notes, images, sounds, animations, and videos [2].

Based on the tools used, multimedia-based learning is more commonly known as ICT learning. In general, ICT is often used to anticipate the saturation of lectures conducted by teachers in learning through the demonstration of cutting-edge programs [3]. Previous researchers suggested several principles and strategies for effective ICT teaching models, namely emphasizing an activity-based...
approach [4], which is adapted to interests and needs in integrating ICT into learning [5], but it must be supported with good content so students are interested in learning and focusing [6]. The use of ICT is divided into three forms, including as a data analysis tool, a problem solving/mathematical modeling tool, and a tool to integrate mathematics with context [7].

However, ICT learning must be understood integrally which involves various elements that must be available simultaneously in order to minimize bias. The ambiguity of the teacher explaining the concept of material that might arise in conveying teaching material can be represented by the presence of ICT-based media used in learning [8], the use of ICT in learning has very good potential as a pedagogical tool if properly utilized [9]. In other words, it can be said that ICT-based learning is an integrated cross-curriculum approach to complement and expand the use of ICT focused on skills in formal education [10]. In general, ICT is often used as an "add-on" in class to demonstrate the latest programs [5], but ICT is also often seen as intimidation and teachers often hate the naïve rhetoric of ICT integration which is usually associated with imperative leadership policies [11] and [3]. Based on the intimidation and naïve rhetoric, anticipation of these factors is needed. One solution is through the selection of ICT learning development models. Tutorial models, drill & practice models, training models and game models are examples of models that are often used in ICT learning.

The tutorial model, drill & practice model, and the training model are models that are designed without inserting the entertainment side while the game model is designed by inserting the entertainment side. The main purpose of using the game model in addition to growing interest in learning mathematics, the game models are also expected to be able to reduce boredom and boredom of students in learning the material. An interest is needed to more effectively integrate ICT in teaching and learning [12]. In addition, interactive mathematical games developed through ICT were allegedly able to maximize student activity because the challenges designed in a game not only function to improve students' cognitive abilities but also affective and psychomotor abilities. The principles and strategies inherent in effective ICT teaching emphasize an activity-based approach [4].

Based on its development of ICT-based learning with a game model known as Digital Game-Based Learning (DGBL). DGBL has been a reference media in the field of education for the past few years [12], Games have a popularity among children and adolescents because they spend a lot of time playing games [13]. The game designed in DGBL aims to promote learning and knowledge development through a form of simulation that allows students to practice their skills in a virtual environment [12]. DGBL has the main characteristics that collaborate between serious learning and interactive entertainment designed to bring cognitive changes to the players [14], therefore it makes sense to combine learning content and game motivation [15].

Some previous research states that the use of multimedia technology in game models is one solution that can be used by teachers to deal with various learning weaknesses [16], provide learning motivation for students [17], as an alternative media that can be used to introduce the concept of arithmetic [18], can help students do a deep cognitive process through a mobilization of concepts designed in a game [12], provides alternatives for students to explore mathematical concepts by suppressing algorithmic skills and saving time [19], able to improve the ability of mathematical representation [20] and mathematical understanding ability [8] at junior high school students, at the level of high school students the use of ICT is able to make mathematics learning more active and fun [21]. Based on this description, we try to develop ICT learning with different terms but have the same principle, namely ICT learning based on interactive games in mathematics learning in the hope of encouraging student learning motivation and facilitating the development of students' mathematical abilities.

### 2. Methods

This study uses the ADDIE model. This model was chosen because it is considered to have an organized, systematic, measurable, and interactive elements that meet the objectives of developing ICT learning based on interactive mathematical games. The stages of the ADDIE model implementation are shown in Figure 1 below.
Figure 1. ADDIE model [22]

Stages of analysis consist of the process of identifying problems, analyzing needs and analyzing tasks to determine media development policies that are relevant to learning needs. The design stage is the stage of drafting a blueprint for media development that is tailored to the design of the learning model that will be used. The stages of development are the processes carried out to implement the design stages. The stages of development should be carried out in accordance with the agreed development plan. Stages of implementation consist of trial steps for the application of instructional media that have been developed directly. Media trials consist of validity tests by experts and practicality tests by users. Expert validity test is carried out by experts in the field of subject matter content and media experts using a questionnaire equipped with suggestions and criticisms. The assessment of experts is based on the following criteria.

| Interval Value | Category   |
|----------------|------------|
| 1.00-2.00      | Not valid  |
| 2.01-3.00      | Less valid |
| 3.01-4.00      | Valid      |
| 4.01-5.00      | Very valid |

Meanwhile, practicality tests were carried out on students and teachers as users using questionnaire instruments and structured interview sheets. Practicality tests by students are usually carried out in three stages orally in individual groups, small groups and large groups. The evaluation phase is the review stage based on the results of the trials (evaluation) which are carried out through qualitative and quantitative data analysis. The evaluation stage aims to determine the feasibility of the product to be mass produced and used. The five stages are stages that must be carried out systematically in a framework of developing instructional media.

3. Results and Discussion

At the analysis stage the research team and the teacher through the FGD. FGDs produce media development policies through the process of problem identification, needs analysis and task analysis. In this analysis phase the researcher succeeded in determining the type of ICT learning to be developed, planning the planning of ICT learning, and preparing the instrument for assessing the feasibility of the media. The type of ICT learning that will be developed is interactive mathematics-based ICT learning game that is developed on the content of algebra material called aljabr domino using Microsoft Power Point. The use of Microsoft Power Point is determined based on several considerations of a simple but compatible tool when used on various devices such as PCs, laptops and Androids. Learning design planning consists of preparing the administrative completeness of the learning implementation plan, learning strategies, and learning achievement assessment instruments. The preparation of the instrument for evaluating the validity of the feasibility test is based on aspects of software engineering, general, presentation, appearance, language feasibility, and audio-visual communication. The instrument for evaluating practicality testing by the teacher is based on the aspects of material appropriateness,
language, presentation of material, appropriateness of the effect of the media on learning strategies, and overall appearance. Meanwhile, the practicality test by students was carried out through the use of a questionnaire consisting of 15 questions consisting of aspects of student interest, material content, and language.

At the design stage the team did the compilation of the ICT development blueprint which consisted of developing an outline of media development, a flowchart and storyboard, and a modular test preparation framework. The outline of media development is compiled by referring to the results of the analysis of planning the design of learning with the type of software that will be used in the development of interactive mathematics games. Flowcharts and storyboards are arranged based on the type of ICT learning based on model games, meanwhile to conduct modular tests the team prepares technical guidelines for implementing modular tests. At the development stage, the research team began to develop interactive mathematical games using special scripts in accordance with the outline of the development of media, flowcharts and storyboards that had been prepared previously. In this step, the team succeeded in developing interactive math games that were ready for modular testing. After the modular test, the interactive math game is declared to be operating properly, the program can be unrolled without obstacles and is ready to be tested at the implementation stage.

At the implementation stage, interactive math games are then tested for validity by experts and practicality tests by teachers and students. The expert validity test was carried out by two experts in the subject matter area and two media experts. The results of the expert validity test are shown in Table 2 below.

Table 2. Test results for the validation of ICT learning based on interactive math games

| Validator       | Value | Category |
|-----------------|-------|----------|
| Media expert I  | 4.84  | Very valid |
| Media expert II | 4.78  | Very valid |
| Content expert I| 4.56  | Very valid |
| Content expert II| 4.68  | Very valid |

The average value of validation of media experts was 4.62 while the average value of validation of content experts was 4.81. Based on these data, ICT learning based on interactive mathematical games that are developed is feasible to enter the practical test phase by teachers and students. The practicality test results of the usage by the teacher get a value of 4.72 while the average practicality test results by students are one to one try out evaluations, small group evaluations, and field evaluations with a total of 20 students getting an average value of 4.63. Based on data analysis as previously shown, we conclude that ICT learning based on interactive mathematical games is feasible to use both based on validation and practicality tests because it is in the very valid category. Meanwhile, based on qualitative analysis, researchers conducted a triangulation analysis of data on the suggestions and criticisms given by experts and teachers. Based on the analysis, it is found that the suitability of suggestions and direction in the form of adding game instructions, adding feedback with the use of creative language, adding images that can increase student interest, improving the structure of language to be easily understood by students, improving readability of content, and improving the symbol of navigation tools so that students can understand it easily.

Furthermore, from the three trials, students highlighted the addition of animated content which they considered was still lacking and the presentation of questions that needed to be added so that the game could be played longer. However, most students gave very good responses and expressed their interest in learning to use ICT based on interactive games. They assume the game is able to increase motivation in learning, learning in that way according to them can eliminate boredom and instead they are challenged to complete learning through games that are served. The response is the same as the results of previous studies which state that the use of ICT in learning mathematics, is able to make learning more active and enjoyable [21] and able to involve the active role of students in learning [23].

In accordance with the advice given during the validity and practicality test, the team made various improvements by accommodating all the suggestions given. In the end all stages of this evaluation can be concluded with the conclusion that ICT learning based on interactive mathematical games is declared
to be the final product both in terms of content, design and nature that are considered user friendly. Based on the evaluation results and some improvements made by accommodating suggestions in the validation and practicality test stages following the display of ICT learning based on interactive mathematical games that were successfully developed.

![Figure 2. Display of the domino algebra interactive mathematics game](image)

At the end of the discussion, the researcher claimed that the product developed was a product suitable for use in mathematics learning. However, several important notes in implementing the product need to be considered including: the teacher's perspective on ICT learning, the creation of a learning environment for students, teacher supervision and guidance, compatibility, feedback features, methods, materials, designs, or models. The challenge in implementing ICT learning is the perception that computers have been seen as inappropriate tools because in addition to potentially damaging health they also risk inhibiting children's intelligence and social skills [24]. This perception must be changed in various ways, including: teacher training [25] which is done to stimulate their confidence and competence [26], involving teachers in ICT development initiatives from the start [27], integrate ICT into the curriculum in designing web-based programs with instructors, educators and researchers, as well as computer engineers [28].

In addition, changes in perception can also be done through the awareness that multimedia tools and designs can make learning more interesting, impressive, and interactive through the use of ICT learning in unique contexts [5], the instructor needs to have high skills in pedagogical, scientific knowledge, be open to new ideas, be flexible and be able to adopt various changes so that the integration between teaching methodology and ICT can be successfully carried out [28]. Furthermore, the learning environment in ICT learning must be understood as a series of gradual dynamic responses to student actions consisting of a set of rules, constraints, and challenges that are appropriate so as to enable students to experience feelings of self-efficacy that can impact on improving learning outcomes oriented to trouble [29].

This is consistent with the findings of other studies that the use of multiplicative mini-games has the possibility of increasing mathematical reasoning if played at home and asked at school, games played at home without attention at school, are ineffective [30], so its use must also go through teacher supervision and guidance [8], especially in supporting children to get and investigate ideas about mathematical concepts [31]. On the other hand, the use of games to teach educational content raises questions about its compatibility with deep learning [32], so that game-based ICT learning can be compatible with the
needs of students, the adaptation process is needed in its development, things that are the focus of adaptation include ways, materials, designs, or models[33], [34]; in addition it is also important to add feedback features [12]. Feedback given in response to challenges in the game can be next step or previous messages, true or false, game over or even designed as another positive message. Positive feedback functions in maintaining and improving the long-term while negative feedback is short-term for improving student performance. Some important notes must be a concern for educators in the development of ICT learning so as to minimize the obstacles encountered when implementing it.

4. Conclusion
Learning ICT based on interactive mathematics games has been successfully developed by meeting the ADDIE development model standards. Based on the evaluation stage, the media is declared suitable for use in mathematics learning both in face-to-face learning in the laboratory and distance learning. Learning ICT based on interactive mathematics games can then be considered to develop mathematical abilities. The game is designed to be able to provide exercises of mathematical problems on the concept of algebra with various levels of difficulty, is expected to be able to provide motivation, learning challenges, and increase students’ mathematical abilities. The researcher realizes that this research has research limitations as a form of imperfection of the researchers' knowledge and experience. A limitation of research that is fully realized by researchers as a drawback that must be completed and continued in further research is the use of algebraic domino games as instructional innovations that can be used to optimize student potential. Based on this, we recommend further research carried out for the purpose of developing students' mathematical abilities in learning algebra.

5. References
[1] Newby T J Stepich D A Russell J D and Lehman J D, 2006 Educational technology for teaching and learning Prentice Hall.
[2] Vaughan T, 2006 Multimedia: Making it work Tata McGraw-Hill Education.
[3] Cuban L, 2009 Oversold and underused Harvard university press.
[4] Thomas L and Knezek D, 2002 Standards for technology-supported learning environments State Educ. Stand. 3, 3 p. 14–20.
[5] Richards C, 2005 The design of effective ICT-supported learning activities: Exemplary models, changing requirements, and new possibilities Lang. Learn. Technol. 9, 1 p. 60–79.
[6] Munir M, 2012 Multimedia konsep & aplikasi dalam pendidikan Bandung Alf.
[7] Amarasinghe R and Lambdin D, 2000 Uses of computer technology in interdisciplinary mathematics learning in International Conference on Learning With Technology, Temple University, Philadelphia, PA.
[8] Umbara U Munir R and Puadi E F W, 2020 The application of ICT learning through Hippipani: the effects on mathematical reasoning ability in Journal of Physics: Conference Series 1521 p. 32010.
[9] Cooper B L and Brna P, 2002 Hidden curriculum, hidden feelings; emotions, relationships and learning with ICT and the whole child in BERA Conference, Exeter, September 2002.
[10] Roblyer M D Edwards J and Havriluk M A, 2000 La integración de la tecnologí a educativa en la enseñanza Up. Saddle River, Nueva Jersey Merrill, 355p.
[11] Healy J M, 2000 Failure to connect: How computers affect our children’s minds: for better or worse Phi Delta Kappan 81, 5 p. 1–11.
[12] Erhel S and Jamet E, 2013 Digital game-based learning: Impact of instructions and feedback on motivation and learning effectiveness Comput. Educ. 67 p. 156–167.
[13] Papastergiou M, 2009 Digital game-based learning in high school computer science education: Impact on educational effectiveness and student motivation Comput. Educ. 52, 1 p. 1–12.
[14] Prensky M, 2001 Digital Game-Based Learning New York: McGraw-Hill.
[15] Prensky M, 2003 Digital game-based learning Comput. Entertain. 1, 1 p. 21.
[16] van Oostendorp H der Spek E D and Linssen J, 2014 Adapting the Complexity Level of a Serious Game to the Proficiency of Players. EAI Endorsed Trans. Serious Games 1, 2 p. e5.
[17] Gee J P, 2005 Learning by design: Good video games as learning machines E-learning Digit.
Media 2, 1 p. 5–16.

[18] Munir Kusnendar J and Rahmadhani, 2016 Developing an effective multimedia in education for special education (MESE): An introduction to arithmetic in AIP Conference Proceedings 1708, 1 p. 50001.

[19] Rahman S A Ghazali M and Ismail Z, 2003 Integrating ICT in mathematics teaching methods course: How has ICT changed student teacher’s perception about problem solving in The Mathematics Education into the 21st Century Project Proceedings of the International Conference The Decidable and the Undecidable in Mathematics Education, Czech Republic.

[20] Umbara U Susilana R Puadi E F W and others, 2019 Increase Representation in Mathematics Classes: Effects of Computer Assisted Instruction Development with Hippo Animator Int. Electron. J. Math. Educ. 15, 2 p. em0567.

[21] Chotimah S Bernard M and Wulandari S M, 2018 Contextual approach using VBA learning media to improve students’ mathematical displacement and disposition ability in Journal of Physics: Conference Series 948, 1 p. 12025.

[22] Branch R M, 2009 Instructional design: The ADDIE approach 722 Springer Science & Business Media.

[23] Oktavianingtyas E Salama F S Fatahillah A Monalisa L A and Setiawan T B, 2018 Development 3D Animated Story as Interactive Learning Media with Lectora Inspire and Plotagon on Direct and Inverse Proportion Subject in Journal of Physics: Conference Series 1108, 1 p. 12111.

[24] McVeigh T and Paton Walsh N, 2000 Computers kill pupils’ creativity Obs. p. 14.

[25] Galanouli D Murphy C and Gardner J, 2004 Teachers’ perceptions of the effectiveness of ICT-competence training Comput. Educ. 43, 1–2 p. 63–79.

[26] Galanouli D Murphy C and Gardner J, 2004 Teachers’ perceptions of the effectiveness of ICT-competence training Comput. Educ. 43, 1–2 p. 63–79.

[27] McVeigh T and Paton Walsh N, 2000 Computers kill pupils’ creativity Obs. p. 14.

[28] Barak M, 2007 Transition from traditional to ICT-enhanced learning environments in undergraduate chemistry courses Comput. Educ. 48, 1 p. 30–43.

[29] Mayer R E and Johnson C I, 2010 Adding instructional features that promote learning in a game-like environment J. Educ. Comput. Res. 42, 3 p. 241–265.

[30] Bakker M van den Heuvel-Panhuizen M and Robitzsch A, 2015 Effects of playing mathematics computer games on primary school students’ multiplicative reasoning ability Contemp. Educ. Psychol. 40 p. 55–71.

[31] Björklund C, 2010 Broadening the horizon: Toddlers’ strategies for learning mathematics Int. J. Early Years Educ. 18, 1 p. 71–84.

[32] Graesser A Chipman P and Leeming F, 2009, Deep learning and emotion in serious games, in Serious games, (Routledge), p. 105–124.

[33] Arnold S Fujima J Karsten A and Simeit H, 2013 Adaptive behavior with user modeling and storyboarding in serious games in 2013 International Conference on Signal-Image Technology & Internet-Based Systems p. 345–350.

[34] Ypsilanti A Vivas A B Räisänen T Viitala M Ijäs T and Ropes D, 2014 Are serious video games something more than a game? A review on the effectiveness of serious games to facilitate intergenerational learning Educ. Inf. Technol. 19, 3 p. 515–529.

Acknowledgments
The author would like to express appreciation and gratitude to the Ministry of Education and Culture and the Ministry of Research and Technology/National Agency for Research and Innovation (Grant: Program Penelitian Kerjasama Antar Perguruan Tinggi, STKIP Muhammadiyah Kuningan dengan Universitas Pendidikan Indonesia Bandung), as well as all parties who have a major impact on the success and completion of this research. The author realizes that this article is far from perfect, therefore constructive criticism and suggestions are needed for the perfection of this article. Hopefully, this research is useful for readers.