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A conventional and digital mathematical board game design and development for use by students in learning arithmetic

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Abstract

This paper reported the design and development of a conventional and digital mathematical board game for use by students in learning arithmetic. At the time of research, there is no significant indication that a mathematical board game is available in scientific and published patent documentation. The availability of mathematical board games for students' drills and practice in arithmetic, especially in mathematical statement construction, would benefit them, as this competency is an essential life skill. This research was conducted through the design and development research method with the procedure of users' need analysis, researcher as developer capability analysis, product design, product development, field testing in its natural setting environment, and the prototype. The board game prototype was developed in both conventional printed and digital versions. The field testing for the conventional printed version was conducted at secondary school classes with 34 and 36 students, respectively, while for the digital by selected participants. The field testing shows that the developed mathematical board game can work as expected in its natural setting environment.

Keywords: Design and Development Research, Digital Board Game, Drill and Practice, Mathematical Board Game, Mathematical Statements Construction

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Many people acknowledged mathematics is one of important learning subjects and a major subject in many national educational curricula. It is also acknowledged that school mathematical skill in mathematical statements construction is important, as this skill will be regularly used in daily life and is required for studying advanced mathematics and other disciplines in the next level of education. As one of learning subjects, mathematics is considered by many students as difficult. To avoid this perception, fun experiences in mathematics learning, such as through games is considered useful.

Learning through games can be considered for use in teaching and learning (Sardone, 2018), building students' capability (Blackman & Belcher, 2017), may benefit as one way of teaching modelling (Burkhardt, 2018), improving children numerical knowledge (Satsangi & Bofferding, 2017; Cheung & Mcbridge, 2017), have impact to training for adults (Libertus et al., 2017) improving mathematical creativity (Park & Lee, 2017), useful in acquisition of mathematical competencies (Skillen, Berner, & Seitz-Stein, 2018), developing mathematical thinking (Fouze & Amit, 2018), have an effect to Children's Interpersonal Understanding (Chou, 2017) and the mobile version of the game

can be used to support education (Nisiotis, 2021). Another article discussed probability learning trajectory regarding game-based learning (Wijaya et al., 2021).

Game design and development for learning is attracted interest of many researchers, such as in traditional game for learning in mathematics, counting and number sense capability can be supported through it (Nasrullah & Zulkardi, 2011) and knowing number facts up to 10 (Putra, Darmawijoyo, Putri & Hertog, 2011). Recently, many new games designed and developed with educational purpose, such as Mallopolis; A Board Game of Megapolitan Urbanization (Piper & Renaud, 2018), Board Game for Physics Classes (Dziob, 2020), and Murder Mystery for engaging mathematics students and mathematicians (Cloft, 2018). Other board games, already protected by patent due to its economic potential, a popular example this is Monopoly, protected by US Patent and Personal Finance, protected by European Patent, and for Mathematical board game, an example of board game protected with Patent is Crossmath protected by US Patent.

However, at the time of research, there is no significant indication that mathematical games, with purposes of learning mathematical statements construction through games is available in scientific and published patent documentations. The search results also indicated that there is not yet available, a game method using a specially designed board, for use by students to learn and drill in mathematical statements construction. Due to these situations, the research question proposed by this research project is how to design and develop a mathematical board game to support students learning mathematical statements construction? Thus, this research project aim is to provide such game for use by students learning arithmetic. The availability of mathematical board games with such purpose would benefit for students, also to provide interesting experiences and popularization of mathematics among school students.

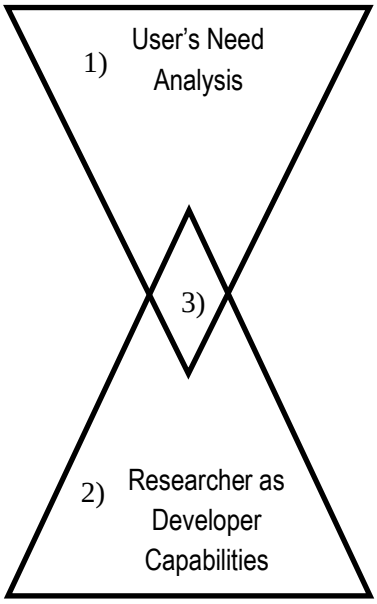
METHODS

This research project was design and development method, with the aim of establishing an empirical basis for the creation of instructional and non-instructional tools (Ross et al., 2008). This research is closely related to mixed methods as following.

> *Design and development research tends to be complex methodologically. This is typically because of the complexities of real-life situations and of the design and development process themselves. This research tends to employ either mixed-method or multiple method approach* (Ross et al., 2008)

The mechanism and procedure as illustrated in Figure 1 was conducted through the following steps: 1) User Need Analysis; 2) Researcher as Developer Capability; 3) Mathematical Board Game Design; 4) Mathematical Board Game Development; 5) Field testing in its Natural Setting Environment; and 6) finalizing the Prototype.

The data is obtained from several instruments consist of 1) User needs analysis questionnaire, 2) teachers survey to know the most suitable games for use by students in mathematics teaching and learning, and 3) Observation sheet to measure the game use in its natural setting environment. This model proposed that, for sustainability, the developed product is intersection between user need and researcher capabilities.



3). Product Design, as intersection between need analysis and development capabilities.

Then followed by
4). Product Development
5). Field testing in Natural Setting Environment
and
6). the Prototype

(Fathurrohman, 2014)

Figure 1. Concept of design and development

RESULTS AND DISCUSSION

A mathematical game scientifically designed and developed based on observation of users need and identification of researchers as developer capabilities. As guided by the design and development method, the intersection of these components is the proposed product to be developed. Result of the designed and developed will be called the prototype to be used by students in class or home.

The initial idea of the board game, came as result of survey with snowball sampling technique to teachers in Banten Province, Indonesia. Results of survey indicated that arithmetic, especially numbers operation is a crucial topic in mathematics and students' capability in constructing mathematical statements is very important for daily life. It was recommended that the mathematical game to deal with numbers and its basic arithmetic operations (+, -, x, and ÷) and other advance number operations, such as root and square number, depend on the school level of the students that playing the game.

Board Game Design and Development

Step 1: Users Need Analysis

Based on the survey, it is noted that the students as potential users of the board games, are familiar with popular board games like monopoly and ladder & snake, in their daily activities. Based on this situation, it was recommended that the learning medium that will be developed was a type of games, especially board game and related with cards and dice. There was a need to develop a mathematical board game, related with cards, and dice, which was familiar for students. The proposed board game, also deal with numbers and its arithmetic operators especially in mathematical statements construction.

Step 2: Researchers as Developers' Capability

The ability of researchers in the field of educational design and development can be measured in their educational product development. The principal researcher has experiences in many research

projects in educational design and development, including through doctoral study related to creating and modifying mathematical learning resources and learning designs. The second and third researchers in some ways have experiences engaging in educational design and development. The research team also can be assisted by students and third parties, such as computer programmer company, if needed regarding design and development of the board game.

Step 3: Board Game Design

Considering user needs (step 1) and researcher as developer capabilities (step 2), orientation of this stage is to find type of mathematical board game, as intersection of user needs and researchers as developer capabilities, which is commonly known to students, teachers, and schools. The board game should be combined with cards and dice into an innovative game that supports mathematical statements construction. The main objective is to play while learning mathematics by arranging mathematical statements, and this activity can be used to distinguish between students who know about numbers and their operations in mathematical equations, with students who unable to construct mathematical statements. For references, researchers scanning the existing relevant educational board games, that already documented in patent-protected inventions. Table 1 list the existing patent-protected board games at the time of research.

Table 1. List of existing patented board games playing methods related to invention

No	Patent Number	Invention Title	Publication Date	Invention abstract
1	US 20100123287 A1 (Winter & Beetem, 2010)	Board Game and Method of Play	May 20, 2010	The present device is a board game for playing a variety of pawn advancement games and comprises a playing board having a central game grid with surrounding borders of different colors. Each colored border has five areas: OUT, PLAY, YES, NO, and WINNERS. Each player is assigned to a colored border and is provided a speared die for rolling, a numbered die for assigning, and at least one pawn. The first player moving all their pawns into their WINNERS area is declared the winner.
2	US 6997457 B2 (Arana & Kaiser-Mistriel, 2006)	Method of playing a game	14 Feb 2006	This is a novel two-player board game which uses addition and subtraction to initiate the movement of a player's pieces. The game is comprised of two sections; each section consists of a plurality of spaces containing integers. The interior section is comprised of opposite sides separated by zeros, one side containing negative integers and the other positive. Pieces are provided to each player for separate use in the exterior and interior sections. Movement is initiated by

					positioning pieces in the exterior section on spaces whose integers produce a difference of two integers found in the interior section, thus enabling the pieces to move from one space to another. The object of this game is integer when added to the equal zero.
3	US 6062562 A (Pardee, 2000)	Board game method of play	May 2000	16,	A novel method of game play utilizing a two-dimensional board having spaces arranged in orthogonal rows and columns in two alternating contrasting colors. Two dice are used as a chance element. Each player is assigned 12 ordinary pieces in one of the colors and a "King" piece. The "King" piece is bi-colored, so that when attacked or captured it may be converted to other colors by inverting it. An additional win situation is to trap the opponent's "King" in a "Chebache" from which it cannot escape

As discussed in the summary for each current and available board game, these available board games do not meet users' needs, and not relevant to mathematical statements constructions. For this reason, a new board game, an innovative, a mathematical game, will be designed to satisfy the users' needs. To make it different, the row for pawn will be in labyrinth intersecting to other labyrinths. Each labyrinth consists of a different instructional square, from the Start to the End. This condition leads to the designing a new board game as displayed Figure 2. The creative work is designed to establish the game flow, from preparation of the game to the start and to the end of the game.

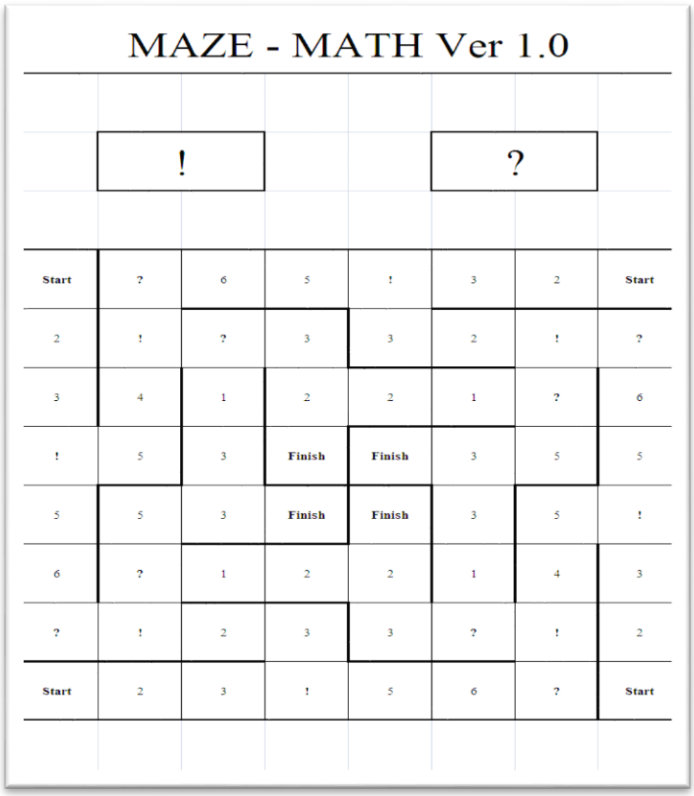


Figure 2. Early design of the proposed board game

The design of playing method is proposed as follow.

1. Preparation of the game
   a. preparing a mathematical labyrinth board game set consisting of:
      - The Mathematical Labyrinth Board, which consists of many instructional squares
      - number cards (1, 2, 3, 4, 5, 6, or n)
      - operation cards ("o"), the variations of operation cards depend on the playing level of users
      - question cards ("?"), the variations of questions cards depend on the playing level of users
      - questions bank, list of questions depends on the playing level of users
      - pawns, and
      - dice

   b. determines the order of players, by throwing dice
   c. each player takes six number cards, with nominal numbers of 1, 2, 3, 4, 5, and 6 and
   d. set the length of play time. Recommended time is 60 minutes or according to players mutual agreement.

Considering potential variation of students as users' capability in mathematical statements construction, different number operations cards, depend on the user level as displayed in Table 2. The number operation used will impact to questions cards and questions bank list used in the game.

Table 2. Number types and operations cards used in the game

No	Level of user	Number types used in the game	Number operations used in the game
1	Elementary School	Integer (0 to 50)	Addition and Subtraction
2	Junior Secondary School	Integer (0 to 200)	Addition, Subtraction, multiplication, and Division
3	Senior Secondary School	Integer (0 to 500) Negative number (-n) Fraction (1/n)	Addition, Subtraction, multiplication, Division, Root, and Square

2. Start the game
   a. rolls the dice by the first player to get a value to determine the number of steps throughout labyrinth.
   b. Pitches by the first player according to the number of steps obtained from rolling the dice, to carry out instructions from the plot where the piece is stopped. The instruction must be obeyed, it will ask the first player to construct mathematical statements constructions, by giving either operation cards (open ended statements) or questions cards (close ended statements)
   c. rolls the dice by the next player to get a value to determine the number of steps throughout labyrinth.
   d. Pitches by the next player according to the number of steps obtained from rolling the dice to carry out instructions from the plot where the piece is stopped. The instruction must be obeyed, it will ask the next player to construct mathematical statements constructions, by giving either operation cards (open ended statements) or questions cards (close ended statements)
   e. repeating the dice throw by the next or return to the first player, to get a value to determine the number of steps.
   f. repeating the cycles, point 1.a to point 1.e, until the end game condition meet.

3. End the game
   a. There is a condition where a player may success in throwing all his number cards by arranging a mathematical statements construction or the game time has reached 60 minutes or game time agreed before or
   b. One of the players' pawn reach "END" square
   c. For point 3.a or 3.b meet, the winner determined based on the nominal amount of all the remaining number cards of each player, with criteria the nominal amount of the smallest number is defined as the winner.

Step 4: Board Game Development

The board game design as explained in step 3 then developed to realize the idea into a concrete form of a mathematical board game. As this development of invention relates to game methods using labyrinth, their processes in which the initial name change from Maze-Math to Mathmaze. The product analysis is carried out to test the use, and problem analysis to realize the designs. There are several variants of labyrinth for this initial design as displayed in Figure 3.

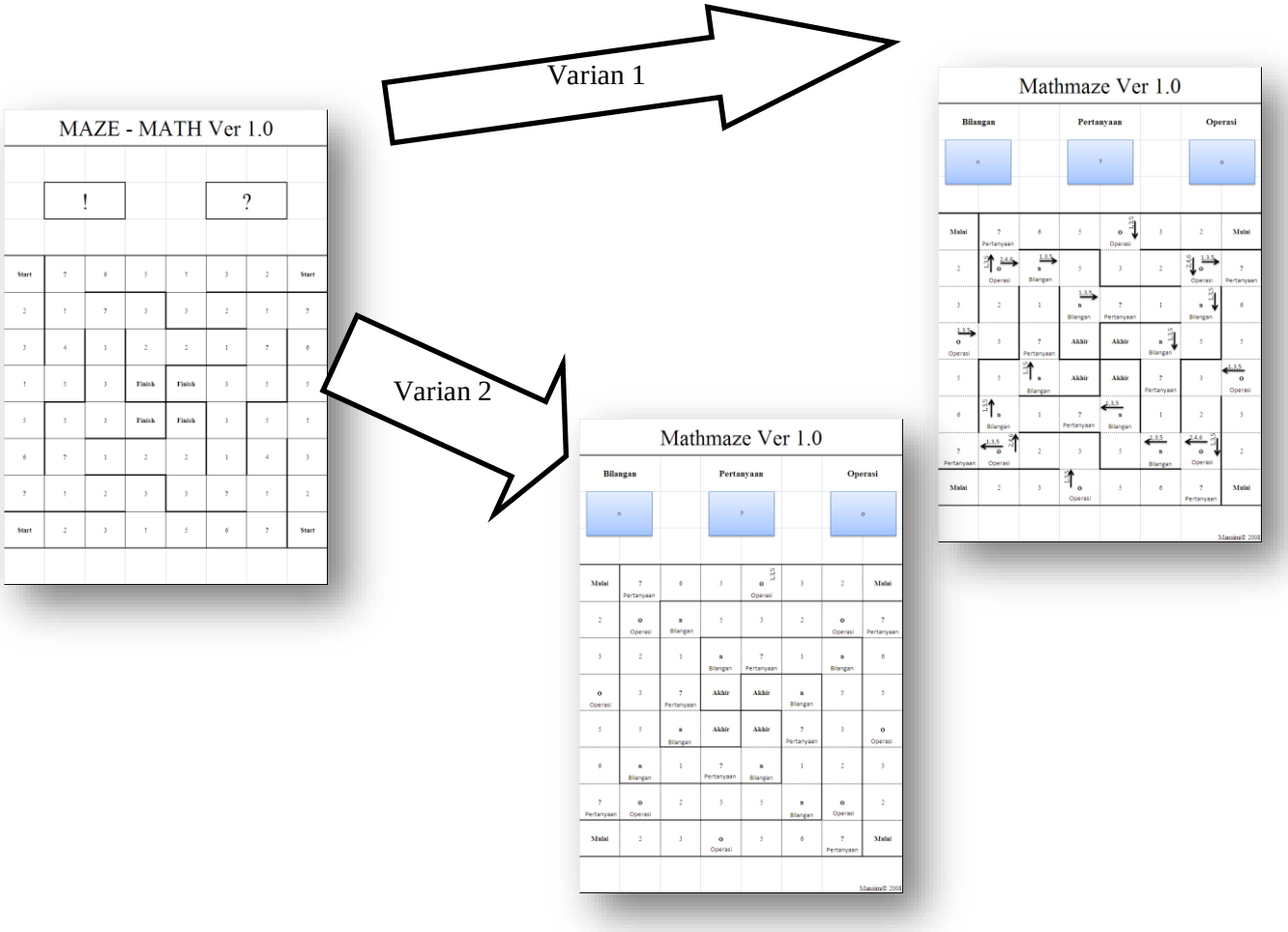


Figure 3. Potential variations of mathematical board game maze

To realize the mathematical board game, earlier version of mathematical board game then printed and used by researchers and other colleagues to test it. Earlier version is board game and cards are printed in paper as displayed in Figure 4 with other equipment such as dice and pawns taken from other available board games.

Figure 4. Original picture of earlier version of the mathematical board game

Following the internal researcher testing with some colleagues in the department, some recommendation then conducted as following: 1) changed the name to the Indonesia term of labyrinth, called *Labirin*; the Mathematical Board Game, (2) minor fixed on the labyrinth layout of the mathematical board game, and (3) revise the long-term planning for this game on how to create a flexible mathematical board game system that could be extended and widely used by many students.

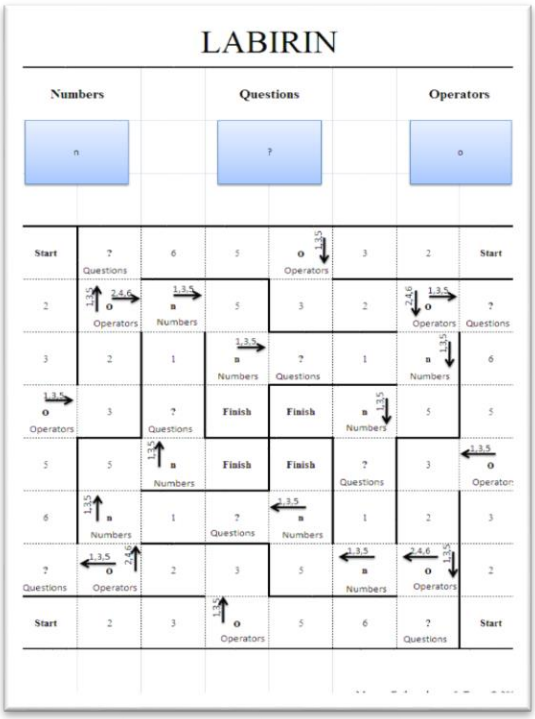


Figure 5. Original layout of the mathematical board game

The final revised board layout of the *Labirin*; the Mathematical Board Game is displayed in Figure 5. This is the final version to be used in the field testing with students as potential users of this game in the future. Through this version, many possible future developments can be started, for example

variations of labyrinth layout, further development to the digital version, and submission to the relevant government office for intellectual property protection.

The game system already arranged to stimulate players constructing mathematical statements to win the game. The more mathematical statements rightly constructed and the more number cards throwed, the player will have bigger chance to win the game. In this scenario, players with smallest number of remaining cards will attempt to immediately reach the "END" plot to end the. The other players strategy is to keep trying to throw their cards by constructing mathematical statements, so that the nominal amount of his/her card number become the smallest. At this situation they will try to End the game by reach the END square or the game time end. The complete procedure of the playing method is displayed in Figure 6.

It is likely many benefits of the digital version of the game, for example user can play again several Artificial Intelligences (AIs) and its feasibility in distribution of the games through personal devices (tablet and smartphone). In today world, the digital version of the games can be available for Android and iOS devices. One example of digital or computerized version of game is Dara; the digital version of traditional game of Macala (Ndukwe, 2014).

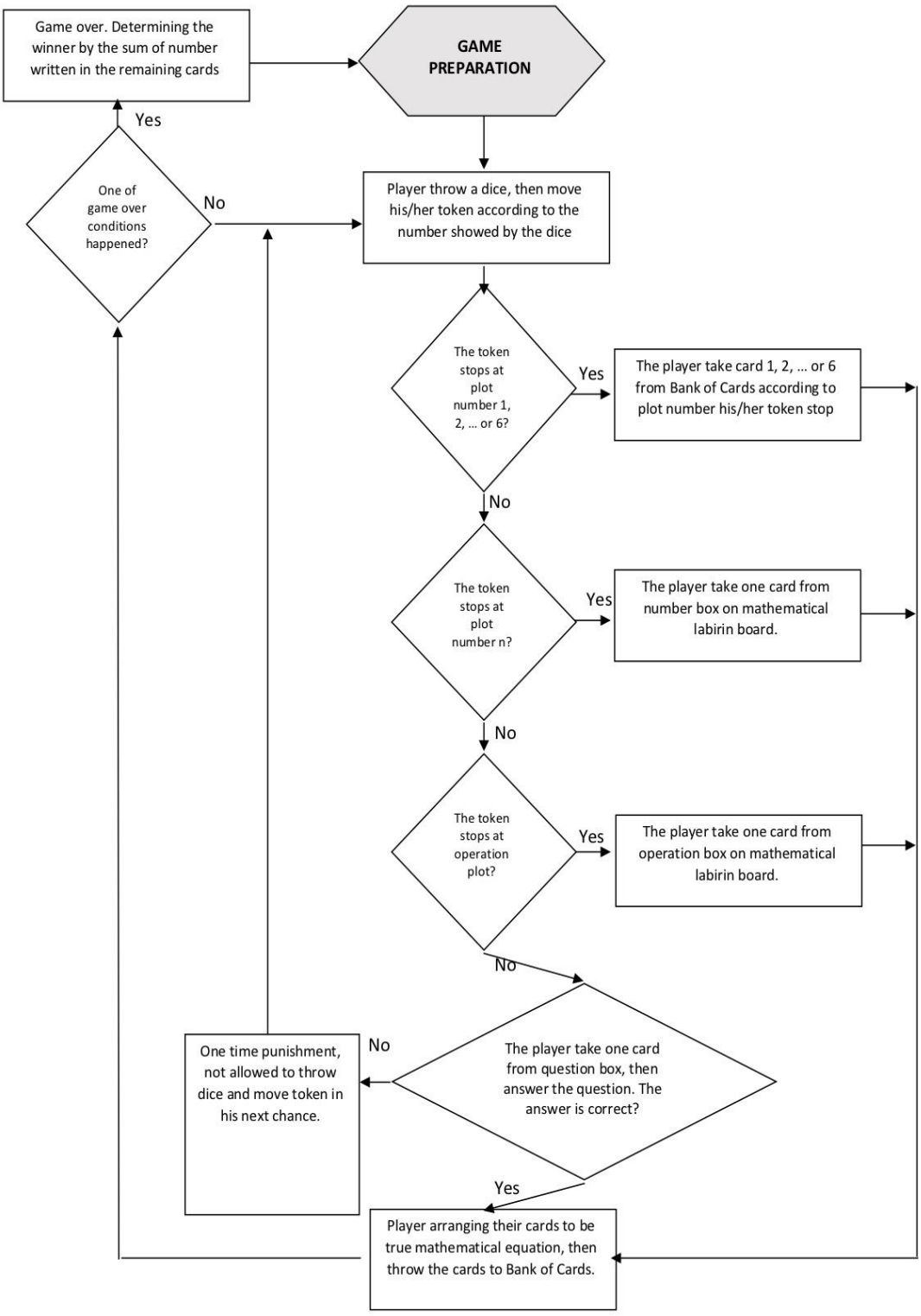


Figure 6. Procedure of playing the mathematical board game

Due to this situation, it is reasonable that the mathematical board game developed can also available not only in conventional printed version, but also in digital version. For that purpose, researchers making collaboration with a third-party game developer to provide the digital version to be available for many people. The early version of digital version is displayed in Figure 7.

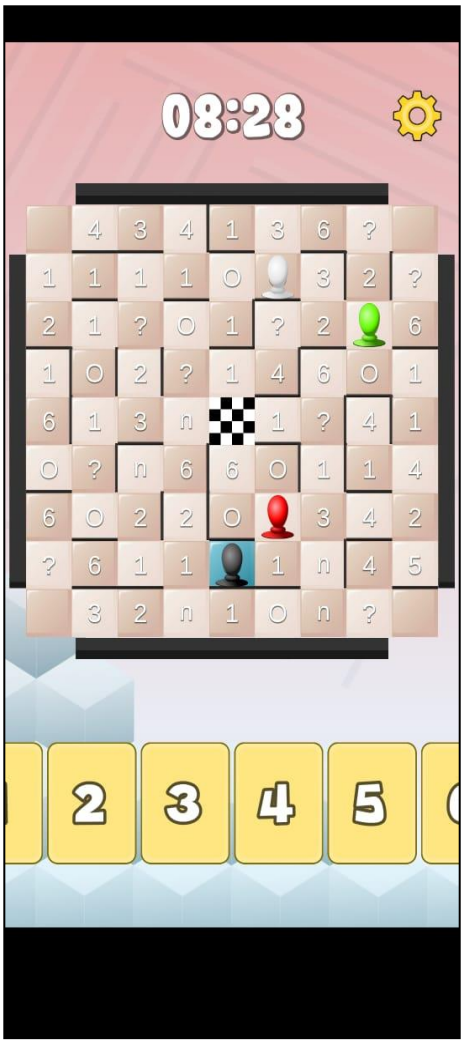


Figure 7. Early version of digital game

In the development of the board game digital version, two board variants (8 x 8 square and 16 x 16 square) were adapted to digital version. The comparison of conventional printed and digital version is displayed in Figure 8.

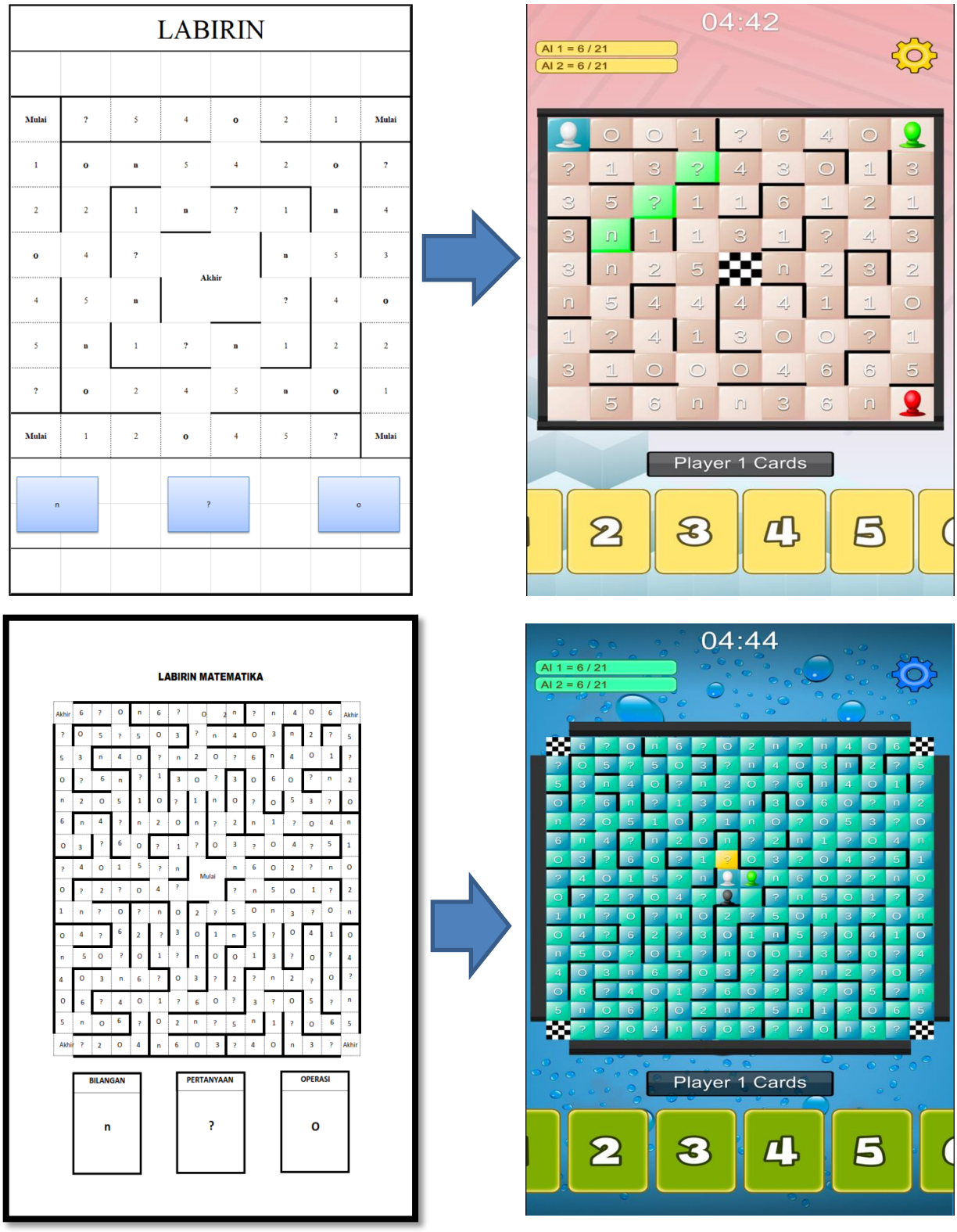


Figure 8. Adaptation of board variants from conventional to digital

It is a nature of digital version, that many features are available only for users in this version:

1. Playing alone through different game levels again computer Artificial Intelligences (AIs)

Figure 9. Screenshot of selecting number of AIs players and the game level

Currently, up to 3 (three) other AIs players are available as partners in learning mathematical statements construction through playing scenarios. Three game levels, at capacity of elementary (around 6 to 12 years old) and secondary school (around 12 to 15 years old), and general (public or more than 15 years old) players, are available. Display to accommodate these is displayed in Figure 9. The different levels will also impact to types of number operations used in each level.

2. Random in board types and cards (numbers, operations, and questions) distribution

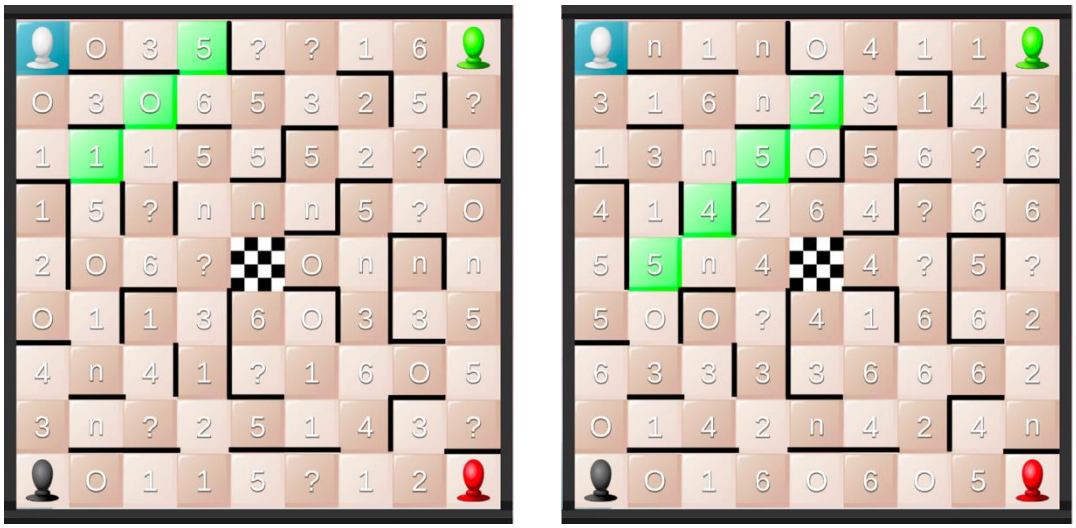


Figure 10. Same labyrinth layout with different (random) number in each square

Taking benefit of computer automatization, number written in each labyrinth block can be varies (Figure 10). This situation provides different game experiences for users. The distribution of numbers, operations, and questions cards can also randomize by computer so that the game can

be fair for all players. For example, the questions displayed in Figure 11 is provided through randomization by computer.

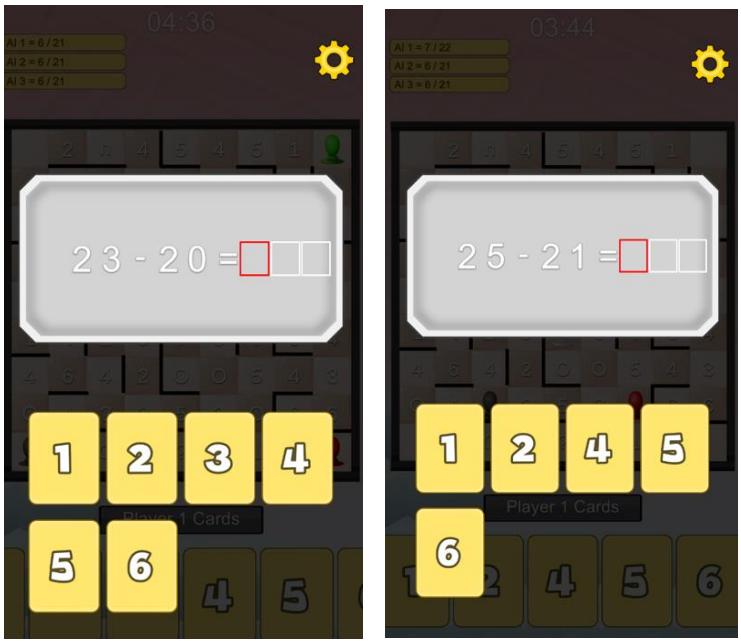


Figure 11. Random questions can be automatically provided by computer

Both randomizations only available in the game digital version. The availability of these randomization can provide different game experiences for players.

3. Sound and game time
   Other features only available in digital games, not in conventional printed version are availability of relaxing sounds during games and setting the playing time limit

Figure 12. Additional setting for sound volume and game time

The in-game sound can be ON or OFF (up to 100%) as needed by players. The game time also can be set to 5 to 30 minutes. The setting page is displayed in Figure 12. According to the rule, if the game is ended due to time, player with criteria the nominal amount of the smallest number is defined as the winner.

Step 5: Field Testing in Natural Setting Environment

Field testing was conducted in an elementary, junior, and senior secondary schools in Cilegon and Serang District. The games rules were adapted for each school level of mathematics competency in constructing mathematical statements. At this testing, in their class, students used this board game.

Figure 13. The use of conventional printed version of the board game by school students

One board game can be used by two to four students, and the students played it about 20 to 60 minutes per session. One board game can be played up to 4 (four) students (Figure 13), so in one class which consist of 30 to 40 students can be grouped to around 6 (six) groups. Table 3 explains a resume of one of students' mathematical board game activities.

Table 3. Resume of students' mathematical board game activities in 60 minutes game in class

No	Students' Activities	Time (minute)											
		5	10	15	20	25	30	35	40	45	50	55	60
1	Hearing direction	V											
2	Making groups	V											
3	Using the mathematical board game		V	V	V	V	V	V	V	V	V	V	
3.1	Exploring maze		V	V	V	V	V	V	V	V	V	V	
3.2	Creating mathematical statements			V	V	V	V	V	V				
3.3	Throwing used cards			V	V	V	V	V	V	V			

3.4	One student win (in one game)	V	V		V			
3.5	Other's students watching and giving support to them	V	V	V	V	V		
3.6	game completed				V	V		
4	Praise the winner					V	V	
5	Conclusion					V	V	

By using this mathematical board game, students not only learn constructing mathematical statements but also competing each other's. To win this game, they must learn and use their skill and knowledge in mathematics, especially skill and knowledge in numbers and basic arithmetic operators by constructing mathematical statements. Beside students, some schoolteachers were giving contribution by testing this board game, then giving suggestion to make this game better. Through interview and questionnaire, teachers expressed their interest to this educational technology.

Important note and recommendations from the users after using the conventional printed version of the mathematical board game as follow:

1. The Board Game should be packaged in a one suite package that include: a. Board Game, b. Dice, c. Pawn, and d. Cards, were arranged in types.
2. The name can be fixed by using the Indonesian language term of labyrinth, so the board game name can be called Labirin; the Mathematical Board Game.
3. List of questions should be more variated.
4. Written Guidance must divide into three groups of Before, While and After playing, and to be more comprehensive.
5. Additional rules regarding criteria of the winner.
6. Improvement of Board Game Design, maze's wall must different than ordinary lines.

Documentation of the use of mathematical board game in the digital version practiced by a student that using this digital game using android simulator in laptop. In the practice, the students can use this as mobile game. Gao, Li, and Sun (2020) already discussed mobile based game for education, for Science, Technology, Engineering, and Mathematics learning. The game features of digital version can be experienced by her without significant assistance by teachers and parents and this situation may be relevant to the increasing need of mobile game-based learning for Covid-19 post-pandemic teaching and learning situation (Eutsler, 2021).

Figure 14. A student use of the digital board game at home

In this setting, the student uses the digital version of the game by playing with two other AIs players (Figure 14), with game time of 10 minutes. She played with different scenarios from elementary to secondary school because this digital game enabled her to try many different settings.

Table 4. Student activities in using board game digital version

No	Students' Activities	Time (minute)		
		5	10	15
1	Starting the game	V		
3.1	Exploring maze	V		
3.2	Creating statements	V	V	
3.3	Throwing used cards	V	V	
3.4	One player win		V	
3.5	game completed		V	
4	Praise the winner		V	
5	Conclusion			V

Student activities is displayed in Table 4. One of question she faced from computer is result of $(13)^2$. To answer this question, she will need to arrange cards number 1, 6, and 9, in which she failed (Figure 15).

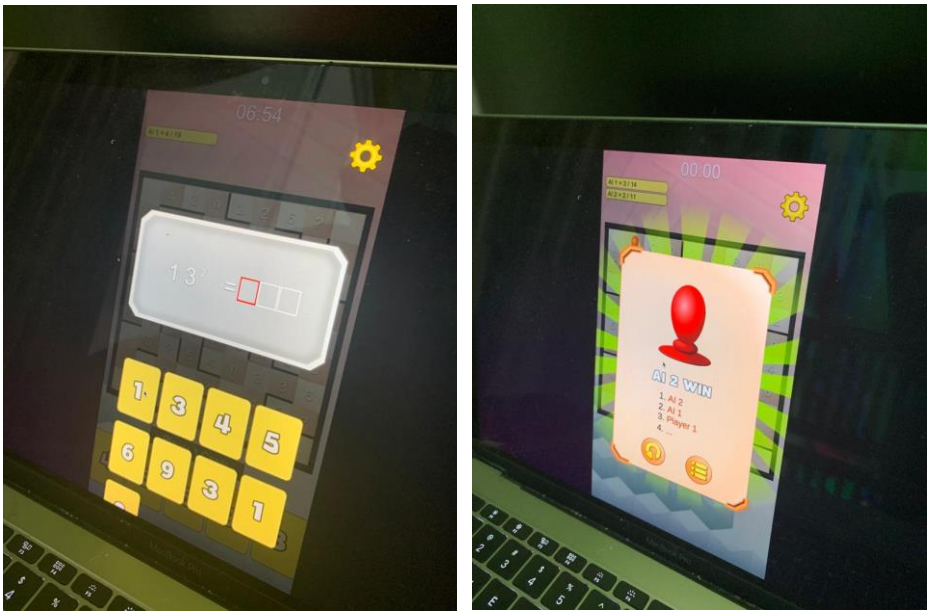


Figure 15. a student use of the digital board game at home

Until the game time ended, no player able to throw all cards to win. So, in the end, the winner is determined by player whose sum of their remaining card numbers lower than other players, resulted to the winner is AI 2 (Computer Artificial Intelligence Player 2). Important note and recommendations from the user and his parent, after using this board game as follow:

1. There is a need additional rule to pass (unable to answer) questions
2. Time to answer question or creating mathematical statements construction is required.
3. Ability to change name of user and to play in multiplayer mode with other students.

In conclusion for testing of this game, both in conventional printed and digital version, the usage indicates that the board game used by students. By observation, the learning process of mathematical statements constructions with this board game can be enjoyable for students. In addition, the results of interviews with students indicate that the use of this medium suggests that learning mathematics is fun and requires students' creativity. This game relates their knowledge to reality in game, and the mathematical statements construction is considered as learning while playing, not a test that burden students. Therefore, it can be claimed that the use of mathematical board games developed is appropriate for students.

In the term of field testing, mathematical board game is working as expected for students of elementary, junior, and senior secondary school with some recommendations for improvement. Researchers can claim that the development of the mathematical board game was successful, and this educational technology can work as expected in its natural setting environment.

Step 6: Finalizing the Prototype

The final prototype then defined as following:

1. The game method is used on a special board, the Mathematical Labyrinth Board composed of several interlinked labyrinths, and each labyrinth consists of many instruction plots, from the Start and to End. The Start and End instruction plot can be in the center, on the edge, and anywhere on the board. In addition, the size of the board can vary. This is different to other board games.

2. The main purpose of the game is to construct mathematical statements. The emphasis on this goal is important because the ability and skill of constructing mathematical statements are very important for the students, for use in everyday life. The game is not limited to addition and subtraction only, but almost all mathematical operations can be used, depending on players' agreement, what level of math operation will be used in the game. In other words, this game method is a way to train students continuously (drilling) constructing mathematical statements through game methods. Using this tool, students become encouraged and eager to learn mathematics, especially in constructing mathematical equations. One related characteristic is the ability to develop mathematical equations to be one indicator for players to quickly win the game.
3. There is a strategy whereby players with the least number of cards will soon attempt to reach the Final Instruction field to immediately win the game. While the other players will try to arrange mathematical equations as much as possible so that the number of number cards owned less and less.

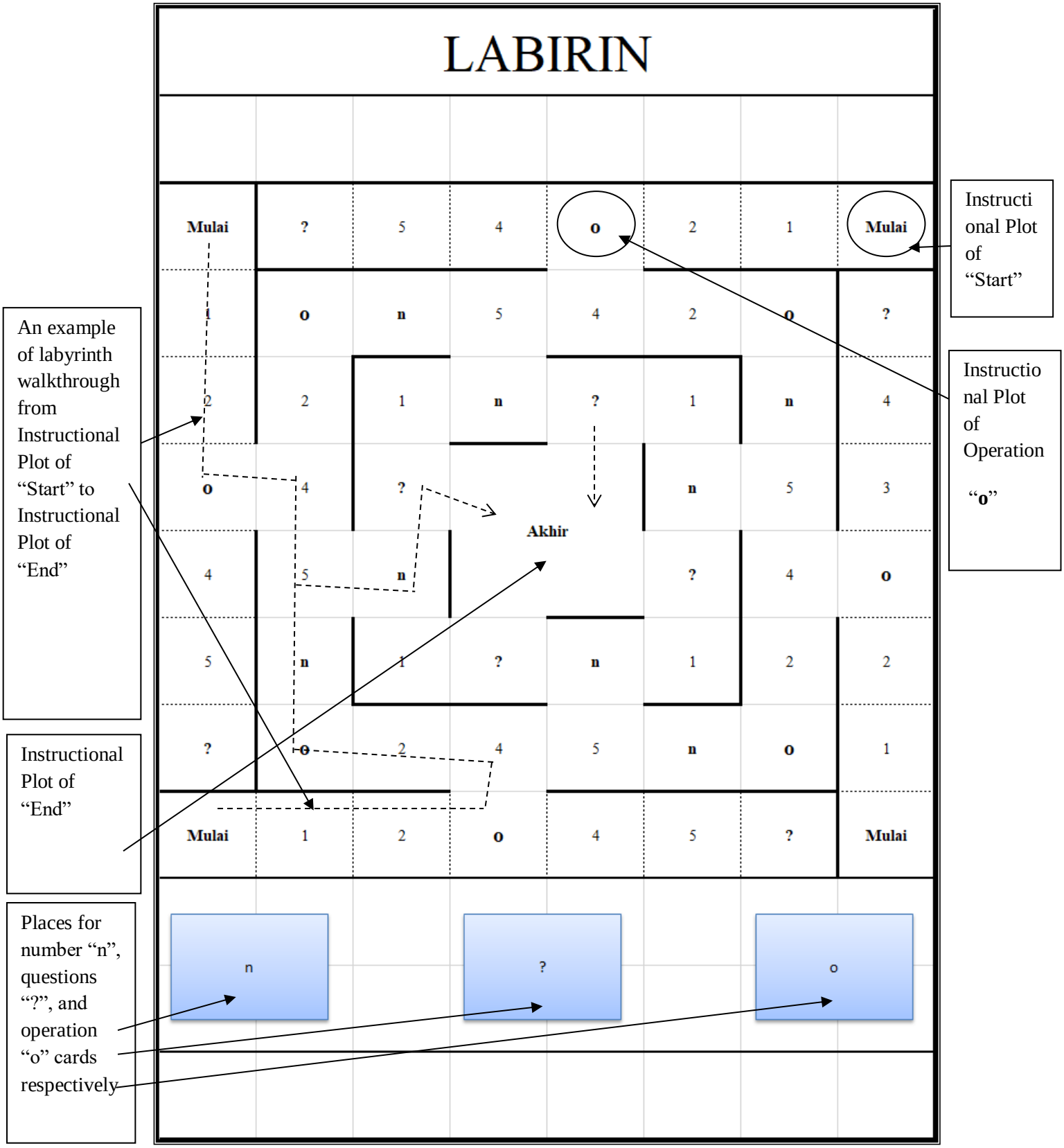
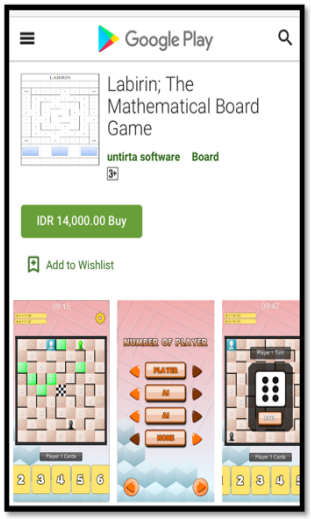


Figure 16. Final original concept board with name Labirin

http://bit.ly/labirinmath



Description

Playing with AI (Artificial Intelligence) in this new and innovative board game. This Patent-Protected Playing Method (IDP 000050494) of Labirin; the Mathematical Board Game is designed to provide fun experiences in mathematics learning, drill in constructing mathematical equations skills that are essential as life skills.

Three level of challenging AIs of Elementary, Secondary, and General (Adult) is available to improve your mathematics skills. Two original and "Exit the Maze" Boards are available.

Features:

1. *Three level of AIs: Elementary, Secondary and General*
2. *Patent-Protected Playing Method, means no other game similar with this educational one.*
3. *Up to 4 players with AIs*
4. *Two boards "Original" (8x8 square) and "Exit the Maze" (16 x 16 square) available. Other boards variants to be available later*
5. *Relaxing Music (On/Off) during playing time.*

Figure 17. Final digital version with name Labirin; the Mathematical Board Game

This version of final prototype then used for intellectual property protection and starting point for future development with brand name of Labirin; the Mathematical Board Game (Figure 16). The final version also reserved by researchers' institution for commercialization or implementation agreement.

The availability of Labirin; the mathematical board game for use by students in learning arithmetic has contributed as additional option of learning experience through game by students, as this product, especially the digital version, can be accessed by public through Playstore (Figure 17). This position, also contribute to potential usefulness of mathematical board game as advocated by Gough (2015) that novel variations with interesting new playing rules can stimulate fresh (mathematical) thinking. In addition to this, Fisher, Hish-Pashek, and Golinkoff (2012) also stated that mathematical thinking can be fostering through playful learning as a key catalyst for ingenious discoveries in mathematics. According to Bayeck (2020) board games allow for various interactions that result in players engaging in computational thinking, teamwork, and creativity while Hendrix, Hojnoski, and Missall (2020) stated that (mathematical) board game play can be useful in promoting numeracy.

Furthermore, the use of mathematical board game and its technology-based version also useful in improving students' mathematical elaboration process (Sung & Song, 2013), students' learning performance (Lin & Cheng, 2022), students' mathematical interest and achievement (Udeh, Edeoga, & Okpube, 2019), students' meaningful interaction (Bastani & Kim, 2020), and also students computational thinking (Liu et al., 2022).

Patent-Protected Prototype

The playing method of Labirin; the mathematical board game already filled for patent-protection to Indonesia Patent Office in Jakarta, Indonesia (Figure 18). After extensive patent process steps, in year 2018 the playing method received notification that its quality and contribution to industry is worth for Patent-Protection.

The potential commercial aspect of the board game already protected, with its general information available for public through permanent link of

https://patentscope.wipo.int/search/en/detail.jsf?docId=ID202901435. The product is classified in International Patent Classification (IPC) as A63F 3/00 (Human Necessities, Games, and Board Game).

REPUBLIK INDONESIA
KEMENTERIAN HUKUM DAN HAK ASASI MANUSIA

SERTIFIKAT PATEN

Menteri Hukum dan Hak Asasi Manusia atas nama Negara Republik Indonesia berdasarkan Undang-Undang Nomor 13 Tahun 2016 tentang Paten, memberikan hak atas Paten kepada:

Nama dan Alamat Pemegang Paten : UNIVERSITAS SULTAN AGENG TIRTAYASA
Jalan Raya Jakarta KM. 4 Pakupatan Serang
INDONESIA

Untuk Invensi dengan Judul : METODE PERMAINAN MENGGUNAKAN PAPAN LABIRIN MATEMATIKA

Inventor : Maman Fathurrohman, S.Pd. Si., MSi., Ph.D
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Perlindungan Paten untuk invensi tersebut diberikan untuk selama 20 tahun terhitung sejak Tanggal Penerimaan (Pasal 22 Undang-Undang Nomor 13 Tahun 2016 tentang Paten).

Sertifikat Paten ini dilampiri dengan deskripsi, klaim, abstrak dan gambar (jika ada) dari invensi yang tidak terpisahkan dari sertifikat ini.

a.n. MENTERI HUKUM DAN HAK ASASI MANUSIA
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Title
[ID] PAPAN PERMAINAN MATEMATIKA LABIRIN

Abstract
[ID]
Invensi ini merupakan metode permainan menggunakan papan labirin matematika, khususnya yang disusun dari beberapa labirin yang saling berkaitan dan setiap labirin terdiri atas sejumlah petak instruksi, berawal dari petak Mulai dan berakhir pada petak Akhir. Dilengkapi alat pendukung metode permainan yang terdiri dari: 1). kartu bilangan (1, 2, 3, 4, 5, 6, 7, 8, 9, 0), 2). kartu operasi ("o"), 3). kartu pertanyaan ("?"), 4). bank soal, 5). bidak, 6). dadu, dan 7). bank kartu, dan digunakan sebagai satu kesatuan alat permainan.

Tujuan invensi adalah untuk melatih pengguna menyusun persamaan matematika melalui metode permainan. Pengguna menyusun persamaan matematika untuk memenangkan permainan. Model dan ukuran labirin yang digunakan pada papan permainan dapat bervariasi. Demikian juga dengan kartu bilangan, kartu operasi bilangan, dan kartu pertanyaan yang digunakan dapat disesuaikan dengan jenjang kemampuan pemainnya.

Invensi ini melatih [drill] pengguna menyusun persamaan matematika melalui metode permainan.

A HUMAN NECESSITIES

63 SPORTS; GAMES; AMUSEMENTS

F CARD, BOARD OR ROULETTE GAMES; INDOOR GAMES USING SMALL MOVING PLAYING BODIES; VIDEO GAMES; GAMES NOT OTHERWISE PROVIDED FOR

3 Board games; Raffle games

Figure 18. Patent Certificate and its information in the WIPO (World Intellectual Property Organization)

Figure 19 explains the English translation of Patent original abstract

> This invention is a game method using mathematical labyrinth boards, typically composed of several interlinked labyrinths and each labyrinth consists of many instruction squares, starting from the START to END squares. Equipped with support tools consisting of 1). number type cards (1, 2, 3, 4, 5, 6, 7, 8, 9, 0), 2); operation type card ("o"), 3); question type card ("?"); 4). question bank; 5). pawns; 6). dice; and 7). bank cards; used as one unified gameplay. The purpose of the invention is to train users to construct mathematical statements through game methods. Users construct mathematical statements to win the game. The model and size of the labyrinth layout used on the board can vary. Similarly, the number cards, number operation cards, and question cards used can be adjusted to the level of ability of players. The invention trains the user to construct mathematical statements through game methods.

Figure 19. The resume or abstract of Labirin; the Mathematical Board Game

Future Variations and Development

There are many future variations and development possible for this product.

1. New Labirin boards with different labyrinth style and sizes
   Beside current standard (8 x 8 square) and large (16 x 16 square) for up to 4 players, in the future the variations in board types (sizes and types) can be provided, for example in round and polygons, not square as its original form.

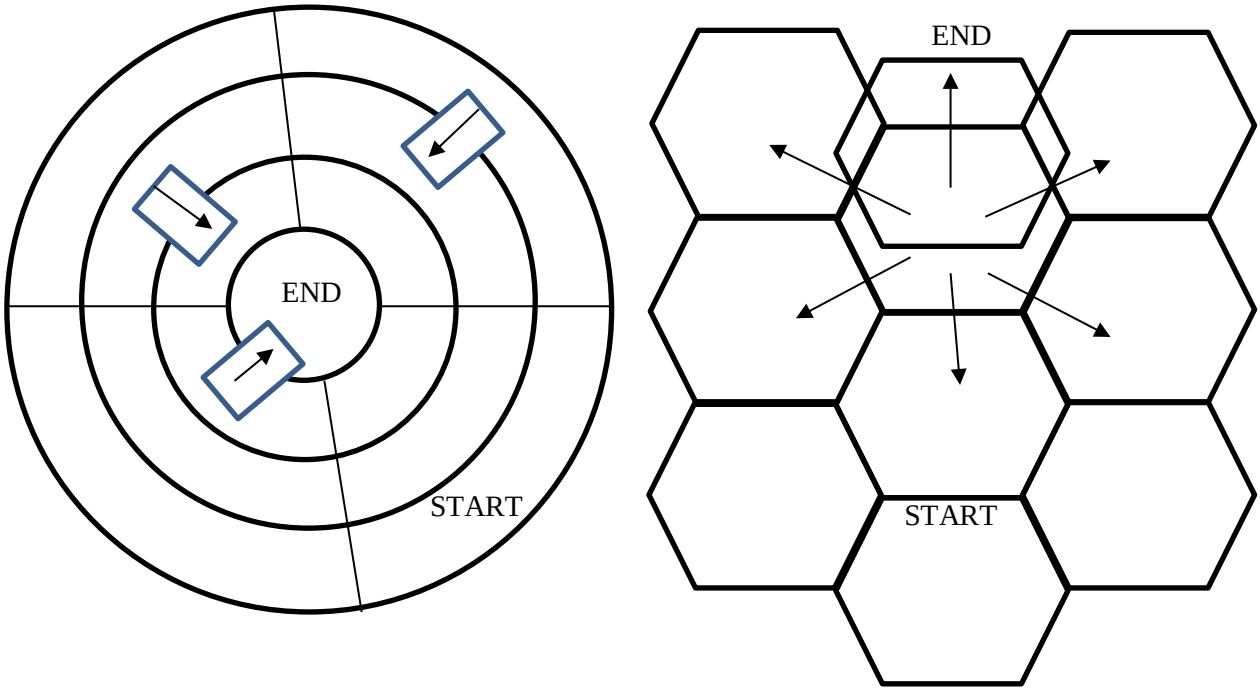

Figure 20. Potential new Labirin board layout

The round type, as also illustrated in Figure 20, enable the circular labyrinth for players while the polygon enables up to 6 (six) directions or options, higher than only maximum 4 (four) directions or options in original square type board. All the variations of boards can used to run the game based on the original game method. In addition, larger (more than 16 x 16 square, for example 32 x 32 square) can be used for more than 4 players. This format of game can be called tournament, in which many players (more than 4) learning mathematical statements creation through playing in one same game at one time. Possibility to get new labirin board already included in the existing digital version, that give information to player that new labirin board can be available later, so they can get new experiences in playing with this game (Figure 21). This situation will be in line with shifting to digital era as discussed by Ioannou (2021). The possibility for extension of the board variations already included in the digital version published in Google Playstore.

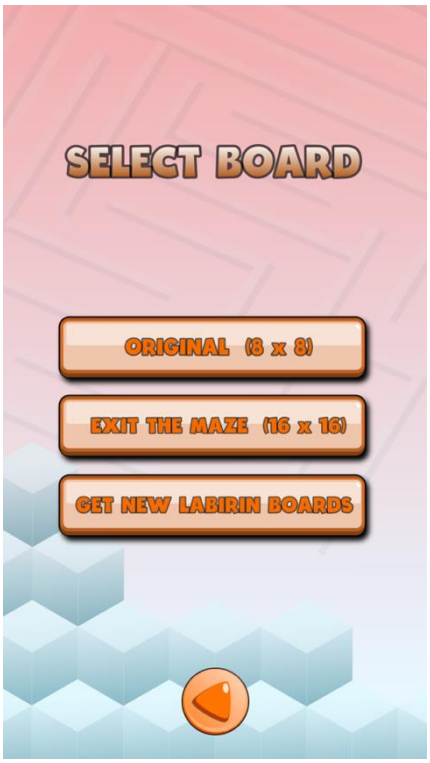

Figure 21. Get new labirin boards button, accommodate in existing digital version

2. Extending potential user ranges, from early childhood to university level/adult
   Further variations will be in extending potential user ranges, not only in existing formal school age (elementary, junior, and secondary school level), but also from early childhood to university level/adult. To extend the possible user ranges, the following extension in number types and number operations as displayed in Table 2 extended to Table 5, can be implemented.

Table 5. Extension of number operation cards used in each level of user

No	Level of user	Number type used in the game	Number operation used in the game	Note
1	Early childhood	Natural number (1 to 9 only	• Number recognition • Addition • Subtraction	New
2	Elementary	Integer (-50 to 50)	• Addition • Subtraction • Multiplication	
3	Junior secondary school	Integer (-500 to 500)	• Addition • Subtraction • Multiplication • Division • Negation • Exponentiation	Already in original game

4	Senior secondary school	Integer (- 100 to 100) Fraction (1/n)	• Addition • Subtraction • Multiplication • Division • Negation • Exponentiation	
5	University level/Adult	Integer (- 100 to 100) Fraction (1/n) Decimal (0, n) Imaginary (in)	• Addition • Subtraction • Multiplication • Division • Negation • Other possible number operations	New

The extension of potential player ranges can provide wider usability of the game users. The user-friendly interface, and adaptation of game method/rules for each user level may need to be taken into consideration.

3. Internet-based/online multiplayer game
   Many games available as internet-based or online multiplayer games, for example online Chess Game that can accommodate players from different countries to play each other in the same game. Like this situation, it is possible that in the future variations and development of Labirin; the Mathematical Board Game also include online multiplayers, depend on demand and/or popularity of this board game in the future. The wide availability of this game for many people, including through internet-based or online multiplayer game version can provide new experiences for many people in learning through playing mathematical statement creation.

CONCLUSION

A conventional and digital mathematical board game already successfully designed, developed, and its method of playing patent protected. The field testing shows that the product in both conventional printed and digital version can work as expected while used by elementary, junior, and senior secondary schools' students.

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Declarations

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Conflict of Interest : The authors declare no conflict of interest.

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