AL-MUDARRIS:journal of education, Vol. 7. No. 2 October 2024
Homepage: https://e-journal.staima-alhikam.ac.id/al-mudarris/index
ISSN: 2620-5831 (print), ISSN: 2620-4355(online)
DOI: https://doi.org/10.32478/al-mudarris.v7i2.2629
Article type: Literature Review

A REVIEW OF THE LITERATURE: THE USAGE OF DIGITAL GAMIFICATION IN EDUCATION TO IMPROVE MATHEMATICAL PROBLEM-SOLVING SKILLS AND MENTAL HEALTH

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Abstract
Mathematics is one of the important subjects for students. Mathematics subjects focus more on the ability to remember, memorize, and interpret. it can train students to think logically, analytically, systematically, critically, and creatively in solving problems. The application of gamification in mathematics is an effective strategy. The use of gamification can also support children's mental health, because the use of gamification can reduce stress levels in children. The purpose of this study is to investigate and analyze research articles that explore the main problems in learning mathematics, how the use of gamification can improve math problem solving skills and support mental health, and problems or obstacles in the application of gamification in learning mathematics. Specifically, this literature review also wants to explain the implementation of gamification in mathematics learning to improve problem solving skills and support mental health. This research is a systematic literature review on the use of gamification in mathematics to improve problem solving skills, this review is limited to peer review articles published between 2019 and 2021. One of the ways used to search for related articles, researchers use the POP (Publish or Perish) application. and other relevant sources. This makes it easier for researchers to identify articles, while for sources, researchers take articles from several publishers such as Scopus, IEEE and Google Scholar. The findings of the data analysis show that the use of gamification in mathematics learning has been carried out in various forms and application models, but its implementation is only limited to improving learning abilities. not many researchers have added mental health aspects in the application of gamification, active student involvement will certainly improve students' mental health, so children are not easily stressed. The use of technology-based gamification applications is the main strategy to improve students' problem solving abilities as well as to improve understanding and learning outcomes and support mental health so that the learning experience becomes durable

Keywords: Gamification, Education, Mathematic, Problem Solving Skill, Mental Health

INTRODUCTION

Competency is one of the 21st-century skills that are the basis for equipping students in the future, which includes four basic skills, as described by the National Education Association (NEA), which includes(Erdogan, 2019, pp. 113–124) Critical

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thinking and problem solving (critical thinking and problem-solving), 2) Creative and innovative (creativity and innovation), 3) Communication (communication), and 4) Collaboration (collaboration). One of the skills that must be honed is problem-solving (Tambunan, 2019, p. 293) mainly for school students. Several subjects focus on this skill, one of which is mathematics. Problem-solving is still an important issue in learning mathematics in schools (Fasni et al., 2017, p. 2).

The core of mathematics is the problem-solving ability(Wangi et al., 2018), in which much of the focus is on the ability to remember, memorize, and interpret (Laksana, 2017). Compulsory mathematics learning is taught to train students to think logically, analytically, systematically, critically, and creatively (Yayuk, 2020, p. 128). Therefore, it takes the ability to think logically, systematically, and analytically to support the ability to solve mathematical problems. Improving students' ability to solve problems is an important goal of teaching mathematics from various stages of education (Al-Khateeb, 2018, p. 178).

In general, learning Mathematics at the school level has not provided many opportunities for students to explore and find answers by using a different way from what is usually taught (Inayahtur Rahma et al., 2023). In fact, teaching in the classroom still tends to focus on ways of solving problems that are usually novel in teaching methods(Ali et al., 2010). This is of course the task of educators to innovate in the learning process, one form of innovation that can be done is by applying gamification in learning.

Gamification is defined as the use of elements in the game in non-game situations (Laksana et al., 2024), there have been many studies discussing the effectiveness of gamification, several studies are explaining that the use of gamification in students' learning processes increases the development of positive learning attitudes (Varannai et al., 2017, p. 1), the use of appropriate and planned elements in the application of gamification in learning activities can motivate students to solve problems and grow their problem-solving skills (Annaggar & Tiemann, 2016). The use of gamification in learning can provoke creative student learning methods so that it has a tremendous effect on increasing the level of learning independence and improving one's skills, especially in mathematics(Udjaja et al., 2018, p. 3861).

Games in education have been studied for the last 40 years(Udjaja et al., 2018). Learning activities that support gamification-based learning can support student learning materials and can train leadership and collaboration skills through imaginative, interesting, and challenging play. Gamification can be interpreted as a design, implementation, and use or the context is not towards games in the form of machines (Laksana et al., 2024). The way gamification works is by making technology more attractive, by encouraging users to engage in the desired behavior, by helping to solve problems(Sun-Lin & Chiou, 2019). It can simply be described that basically students are very interested in something fun, such as the use of gamification. Gamification is a learning approach using elements in games or video games to motivate students in the learning process and maximize feelings of enjoyment and engagement with the learning process(Kotob & Ibrahim, 2019), in addition, by incorporating game elements in the learning process will make students more enthusiastic, which in the end students will

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enter and follow the learning process.This method can be used to capture interesting things. Students' interests and inspire them to continue learning (Faizah et al., 2024).

The implementation of the use of gamification in the learning of school student has been widely applied, such as the use of the Kahoot and Quizzes applications which are often used in the learning process, because they are easy to configure and apply in learning (Legaki et al., 2020). In another study proved that the use of gamification in astronomy learning at the school level can increase students' learning motivation. The core elements of the game (rules, system feedback, and voluntary participation) are integrated into learning activities so that students can interact collaboratively so that they can develop skills and competencies in a shared space (system) (Cunha et al., 2019).

Applying gamification in the context of learning, In addition to increasing the level of student motivation, learning is driven from interaction activities with games. As has been explained, that by applying gamification in the learning process can integrate learning and play, so it is very possible to improve the learning and training process, to improve learning outcomes, cognitive abilities, and further if done continuously can improve problem-solving abilities for certain subjects.

Mathematics is one of the subjects taught at the school level, this subject is one of the subjects in which a lot of focus is on the ability to remember, memorize, and interpret. Compulsory mathematics learning is taught to train students to think logically, analytically, systematically, critically, and creatively. Kirisci further explained that the core of Mathematics is the problem-solving ability (Kirisci et al., 2020).

A framework for problem-solving is a design that informs a deeper understanding of an iterative process that serves to support and enable students to grow through the guidance of more experts and peers, therefore it requires the ability to think logically, systematically, and analytically to support the ability to solve mathematical problems. Improving students' ability to solve problems is an important goal of teaching mathematics from various stages of education. Understanding that problem solving is important in mathematics learning The National Council of Teachers of Mathematics explains that problem-solving is part of all subject areas, problem-solving activities should not be an isolated part of the lesson, unit, or curriculum but should be integrated into the experience students, involve important mathematics, and are connected to various processes and material descriptions. Integration to create new experiences for these students can be done using gamification strategies.

Building student experience through gamification strategies makes learning mathematics more fun, especially in learning basic mathematics, through learning experiences. Student are empowered in roles in games, they work in groups. Important to note is the determination of the elements in gamification that can be applied in learning mathematics, especially in terms of solving students' mathematical problems.

In general, it can be described the elements in gamification that can be applied in learning mathematics for school using the MDA framework (standing for Mechanics, Dynamics, and Aesthetics according to table 1.

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Table 1. Division of Gamified Elements Using MDA Framework (Hunicke et al., 2004)

MDA Framework	Description
Game mechanics	Points, Levels, Challenges, Virtual, Goods, Leader-Boards, Badges, Gifts, and Charity
Game dynamics	Reward, Status, Achievement, Self-Expression, Competition, Altruism
Game Aesthetics	Satisfaction, Pleasure, Envy, Respect, Connection

This study will provide some findings and insights, especially for researchers whose focus is on the use of gamification in learning mathematics, this research contributes and contributes in the form of scientific ideas or ideas about gamification, where this research is taken from several relevant studies as contributions. Mainly related to students' mathematical problem solving abilities, in a study it was explained that students' connections in solving mathematical problems were very low and weak (Kenedi, 2019, p. 75), with the use of elements in gamification in the learning process can improve students' abilities in solving mathematical problems and mental health, where it is still considered difficult and boring for students

METHOD

This study uses the Systematic Literature Review (SLR) model in conducting a comprehensive analysis of the application of gamification in mathematics learning (Grande-de-Prado et al., 2020). Here we also use keywords that are used as references or guidelines in finding appropriate literature sources, including "issues about the mathematics learning", "gamification in Mathematic learning", "problem solving with gamification", "Implementation gamification for mental helath".

To develop a framework that will be used as a reference in this research, first exploratory research is conducted which consists of the study of material related to the topic of gamification in mathematics learning, to find and strengthen ideas. The database in this study is data from Science Direct, IEEE Xplore, and Springer. to facilitate our search, we are assisted by the PoP (Publish or Parish) application, this application makes it easier for us to search for related articles.

Some of these articles were analyzed both from the title, abstract and content of the article, then the researcher set some questions that were taken based on the content of the article and the elaboration process by the researcher. the questions include:

Table 1. Research Questions

Question	Description
What are the main problems in learning mathematics?	It aims to explain various problems about mathematics learning that have not been solved

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What is the role of digital gamification in improving mathematical problem-solving skills and mental health?	This explains the role of digital gamification in overcoming the problems that exist in learning mathematics dan improve mental helath
What are the problems or obstacles in the application of gamification in learning mathematics?	This explains the problems or obstacles in the application of gamification in learning mathematics at the school level

Determination of the criteria for excluded articles is very limited by considering the titles and keywords found are similar to the keywords being searched for, then the selected articles must be published by well-known publishers besides that the impact factor is also one of the criteria, articles that use languages other than English is also excluded. To determine the quality of the article, the article must meet the following criteria:

1. Consistency: Are the research objectives consistent with the research results?
2. Data Collection: Was the data collection appropriate and answered the research question?
3. Data Analysis: How do they analyze the data?
4. Results: Can the results explore the use of gamification in learning mathematics? and the use of gamification applications to improve mathematical problem solving skills?

To facilitate an understanding of the data extraction process in systematic literature review research, it can be seen in figure 1.

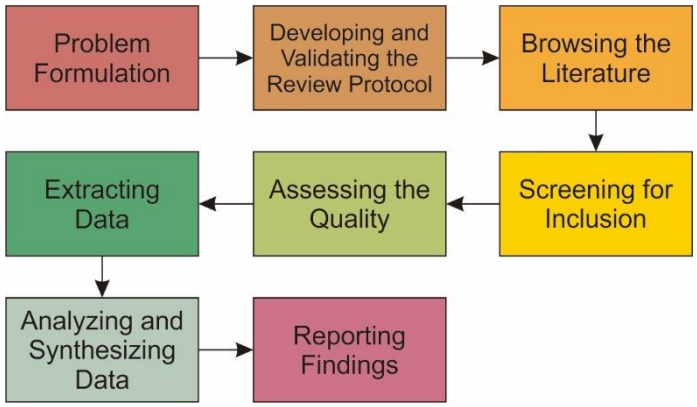

Fig. 1 Systematic Literature Review flow process (Xiao & Watson, 2019)

RESULT AND DISCUSSION

This section will discuss the data validation process which includes data identification and selection, data extraction, and results. In addition, this paper will answer the questions contained in the methodology as a basis for considering the importance of gamification research in learning mathematics in improving problem solving skills, then

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Data validation

This systematic literature review model tries to compare and classify the use of gamification in learning mathematics. This SLR review can be seen in general, but some limitations are adjusted to the two types of criteria specified. Threats to validity include Threats to Identification and Selection of Primary Studies, Threats to Data Extraction, and Threats to Synthesis and Results.

Identification and selection of primary studies

In the identification and paper selection process, we try to provide deeper insight and information related to the use of gamification in school mathematics learning, in the next stage, we collect as much as possible about the primary data used for the knowledge extraction process so that there is no bias. We, therefore, determined criteria for listing and classifying as much primary data as possible. In terms of the selection process, we included all related articles or research studies and did not evaluate these studies by assigning a quality score. Here we present the identification data and the selection of the main study.

Table 2. mains themes of study

Author	Title	Mathematics learning	gamification in learning	problem solving with gamification	Mental Health
Diana R. Sancheza, Markus Langerb, Rupinder Kaura (2020)	Gamification in the classroom: Examining the impact of gamified quizzes on student learning		x		
Farida Puput Lestari, Farid Ahmadi, Rochmad (2021)	The Implementation of Mathematics Comic through Contextual Teaching and Learning to Improve Critical Thinking Ability and Character	x			
Yogi Udjaja, Vincent Sadino Guizot, Natalia Chandra (2018)	Gamification for Elementary Mathematics Learning in Indonesia	x	x	x	
Kyohei Sakai and Shingo Shiota (2016)	A Practical Study Of Mathematics Education Using Gamification	x	x		
Liljedahl, P., Santos-Trigo, M., Malaspina, U., and Bruder, R (2016)	Problem Solving in Mathematics Education	x		x	
Dicheva, D., Dichev, C., Agre, G. and Angelova, G (2015)	Gamification in Education: A Systematic Mapping Study		x		
Allen Lai (2014)	A Study of Gamification Techniques in Mathematics Education		x	x	
Cunha, Geovania Cezana Araujo Barraqui, Luciana	Evaluating the use of gamification in mathematics	x	x	x	

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Pelissari De Freitas, Sergio Antonio Andrade (2018)	learning in primary school children			
Michael Meder dan Brijnesh-Johannes Jain (2014)	The Gamification Design Problem	x	x	
Nisaul Barokati Seliro Wangi1, Punaji Setyosari, Dedi Kuswandi, Wasis D Dwiyogo (2018)	Gamification as a Strategy to Improve Student Learning Motivation : Preparing Student for 21st Century	x	x	
Sun-Lin, Hong Zheng, Chiou, Guey Fa (2019)	Effects of gamified comparison on sixth graders' algebra word problem solving and learning attitude	x	x	
Kalogiannakis, Michail Papadakis, Stamatios (2021)	Gamification in Science Education. A Systematic Review of the Literature	x		
Putz, Lisa-maria Hofbauer, Florian Treiblmaier, Horst (2020)	Can gamification help to improve education? Findings from a longitudinal study	x	x	
Emma Nuraihan Mior Ibrahim, Nurulfitrie Jamali and Ahmad Iqbal Hakim Suhaimi (2021)	Exploring gamification design elements for mental health support Emma	x		x
Vanessa Wan Sze Cheng, Tracey Davenport, Daniel Johnson, Kellie Vella, Ian B Hickie (2019)	Gamification in Apps and Technologies for Improving Mental Health and Well-Being: Systematic Review	x		x
Mikael Vejdemo-Johansson, Justin Curry, and Julie Corrigan (2019)	Mental Health in the Mathematics Community	x		x

Data Extraction

Based on the explanation described in point Identification and selection of primary studies, we collect as many articles or research studies as possible from various scientific sources related to the keywords that have been determined, including primary data and secondary data, without giving us a quality score, where the function is to select related articles that help in prioritizing the results and trends of the intended research, of course, this is a threat to data extraction. Besides that, there is another threat, namely in the form of article data obtained from the research questions that have been made in point III (methodology), of course, there will be other considerations used to research the use of

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gamification in mathematics learning. Then we identified and eliminated them using the spesific keyword, "gamification mathematics problem solving and mental health."

FINDINGS AND DISCUSSION

Based on the search results and also the selection of articles from several sources, research on gamification in improving mathematical problem solving skills can be a concern for the world of education, given the very small number of studies. In formulating this research further, there are three questions that become the basis or footing for stepping into gamification research.

Question 1: What are the main problems in learning mathematics?

Mathematics is still a problem in learning, especially at the school level. Among the problems that occur are that there is still many students' achievement in mathematics subjects that tend to be less good, many students are less interested in studying mathematics seriously because they think mathematics is a boring subject, besides that many teachers have difficulty teaching mathematics conceptually (Subarinah, 2011).

Many students are taught the old ways such as memorizing and distributing questions, it is undeniable that this method is also very good, but if it is not packaged in fun learning, it will certainly make students bored and consider mathematics as an unpleasant subject.

This is due to the lack of creativity and innovation from the teacher. Support from parents is also one of the determining factors for the success of learning mathematics in children (Ramani & Scalise, 2020) Developing children's early math skills are very important because early math skills will be a strong and stable predictor of their later math achievement (Duncan et al., 2018). Children from childhood have been given a natural interest in learning mathematics, they also have various mathematical competencies in different sub-domains of mathematics, such as number knowledge and spatial competence (Verbruggen et al., 2021).

The problems that occur are many who have not explored deeply about children's natural interest in learning mathematics, more tend to use a mathematical learning approach that is still theoretical, abstract and does not pay attention to context, In the end, children will experience stress due to a lack of understanding of the material in mathematics, so this can interfere with children's mental health, because stress is the main factor that triggers or worsens mental illness (Vejdemo-Johansson et al., 2019).

Mental health disorders are a global public health problem today. This has become an important agenda for the Sustainable Development Goals (SDGs). The goal is to change the world by ensuring healthy lives and promoting well-being that includes mental health for all ages by 2030 (Ibrahim et al., 2021). Problems that occur in learning mathematics need to find solutions, by way of presents interesting and fun mathematics learning for students, because the essence of learning mathematics is a fun learning environment (Bellos, 2010).

Providing extrinsic and intrinsic motivation is very much needed in maintaining mental health, a study says that giving intrinsic and extrinsic motivation can improve a person's performance, but only intrinsic motivation is directly related to improving mental health, creativity, learning outcomes, and involvement in a positive way. directly in an

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activity (Kalogiannakis & Papadakis, 2021, p. 4), In this case, the provision of stimulation from the outside is also very much needed, especially for subjects that are considered difficult for children. The use of gamification in learning can stimulate children's learning abilities and motivation. The game and gamification approach is useful for mental health recovery that utilizes various processes that include educating, motivating as health support.

Question 2: What is the role of digital gamification in improving mathematical problem-solving skills and mental health?

Gamification is a design process that focuses on people, feelings, and motivations(Reigeluth & An, 2020). Especially in the delivery of mathematics material for school children. The use of gamification in the learning process can provide maximum results and make learning more meaningful. Use of gamification can be used as a stimulus in stimulating children to think and act (core drive 3) (Reigeluth, n.d.)Gamification in learning can be defined as a method of how to use game-based mechanics, thinking, and aesthetics to engage and motivate students to engage in their learning, and problem-solving(Yamani, 2021, p. 19).

Gamification is a creative learning method that has tremendous influence in increasing the level of independent learning and improving one's skills, especially in realistic mathematics lessons. The use of gamification combined in the learning process is one of the innovative solutions, which is expected to help teachers, especially mathematics subjects, in the learning process. In the context of problem-solving, this model is very effective for internalizing important cognitive processes for students.

A study gave good results on the use of gamification in mathematics learning, the results of the study showed that students felt interested and happy in learning mathematics, with a percentage of 66.9% and if measured from the level of assistance in learning with the gamification approach it contributed 75.4%, meaning this gives a positive value to learning.

Correspondingly Duncan (Duncan et al., 2018, p. 24) explained in his research that a problem-solving approach, using several aspects of gamification, through role-playing and mystery, through receiving a 'mystery' package can add value to the learner's experience. However, to strengthen the learning experience of students, and apply every element in gamification so that learning becomes more meaningful. Reiguluth said that the learning experience with gamification should include not only explicit engagement but also meaningful learning (Beatty & Myers, n.d., p. 272) so that it has an impact on the final result, collaboration is needed, in this case, it collaborates with a learning model. An article explained that the learning model in collaboration with gamification shows that multisensory in children can increase performance and potential in students and activate user involvement, to intensify the role of presence and trigger specific emotional responses in educational games (Covaci et al., 2018).

This approach is more comprehensive and also provides additional guidance on how to support students through the actual problem-solving process. The application of gamification can improve mathematical problem-solving skills and mental health can be seen from one of the indicators used in solving mathematical problems as expressed by NCTM, namely, Apply and adapt a variety of appropriate strategies to solve problems

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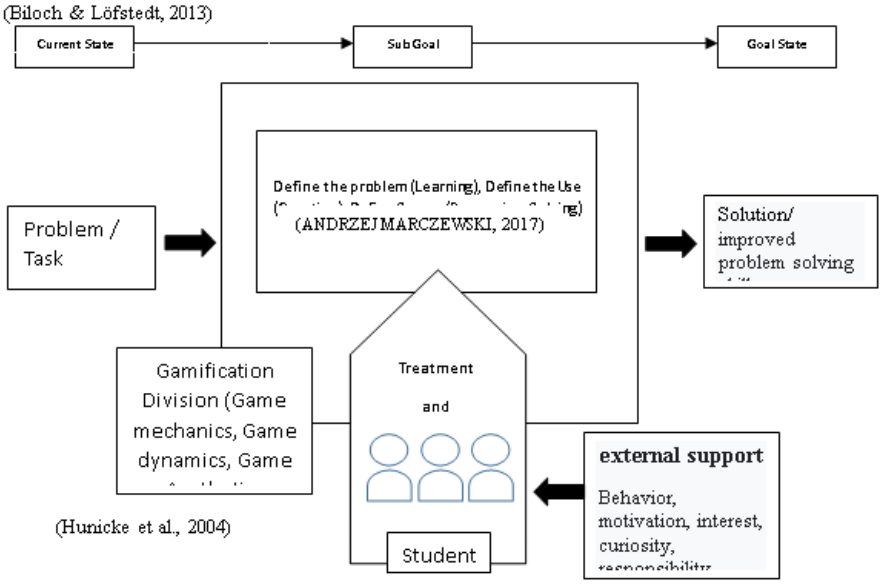
(NCTM, 2003), when the problem-solving task is integrated. by using the elements contained in gamification, learning becomes more fun, This of course also has a positive impact on children's mental health, achievements when playing games can divert stress and improve social relationships, a study revealed that games such as "Modern Air Combat", "Tetris" have been shown to reduce trauma to children. In addition, this integration can provide learning feedback to students and track their progress in knowledge acquisition.

Through gamification, students can obtain information about their achievements. However, game design must demonstrate its effectiveness in supporting mental health, this of course requires considerations in the form of new models that support mental health and problem solving.

Based on these data, the use of gamification can be applied in learning mathematics, especially in terms of training students in solving problems and mental health. The gamification design framework that has been designed above can be implemented into the student's study room, support from technology, thus increasing the enthusiasm for learning for students (Verbruggen et al., 2021). In general, the appearance of learning using gamification can be seen in figure 2

Fig. 2 Desain Framework The Usage Of Digital Gamification To Improve Mathematical Problem-Solving Skills



Question 3: What are the problems or obstacles in applying digital gamification in learning mathematics?

Many data show that the use of gamification in learning mathematics shows positive results, including increasing learning motivation. through learning with gamification students have the opportunity to improve problem-solving skills because they can spend hours applying them in games (Turan et al., 2016). However, in its implementation, it does not always experience success, there are many obstacles or

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problems encountered in its implementation. Several research results found that the use of gamification was not fully effective, improper use would make learning ineffective. Research from Jan Broer shows that the implementation of gamification understudy shows that its effect on motivation or participation is much lower than the hype that people previously believed (Broer, 2014, p. 393).

Of course, this problem is based on various factors, both from educators and students. The most visible reason is that there are differences in the motivation of students, some use it for learning while others only use it for playing, Ismail also expressed the same thing, in his study showing the results that students were less motivated in the gamification method because students feel unprepared with this new method. Moving on from the data, of course, it is necessary to pay close attention to the implementation of gamification in learning mathematics. Several things need to be considered in implementing gamification in learning. First, identify in advance the purpose of the learning that will be carried out, of course, makes it easier for the teacher in terms of directing students to learn. Second, if we use technology, then identify which technology and game mechanisms are good for achieving these learning objectives, and reflect the characteristics of students (Persephone Rizvi, 2019).

Third, combining fun game mechanics, providing useful and meaningful gameplay, thus making students motivated to keep playing and learning.

Fourth, what needs to be considered is the accuracy in inserting gamification elements into gamification-based applications, of course, the selection of the right elements can increase learning activity and motivate students to be actively involved in learning (Alsubhi & Sahari, 2020). Below will be shown an example of the use of digital gamification and its flow

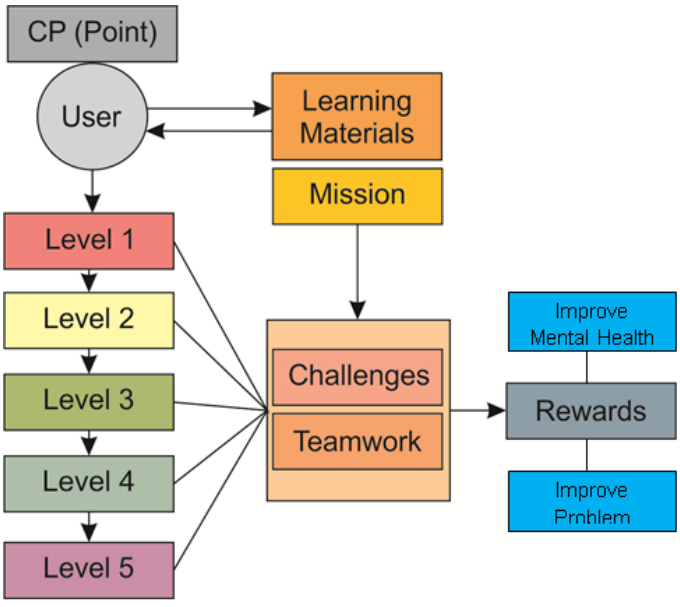

Fig. 3 The flow of mathematics learning scenarios using gamification elements

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AL-MUDARRIS:journal of education, Vol. 7. No. 2 October 2024
Homepage: https://e-journal.staima-alhikam.ac.id/al-mudarris/index
ISSN: 2620-5831 (print), ISSN: 2620-4355(online)
DOI: https://doi.org/10.32478/al-mudarris.v7i2.2629
Article type: Literature Review

In this flow, the user or student uses an application that has been designed by incorporating gamification elements that support mathematics learning, which can be explained more clearly as follows:

1. On the first slide, students enter the application, then students are asked to choose a character that has been provided, each character has different skills or abilities.
2. On the second slide, students will be explained using the application, then students are guided to enter into the storyline, which will contain some math materials for school in the form of attractive icons, then asked to choose.
3. On the third slide, students will be explained in advance about the material and there will be several more specific explanations, including that students will be invited to follow each flow of problem-solving by referring to the problem-solving technique of the Mean Ends Analysis model, which includes: simpler sub-problems, b) Sub-problems that have been compiled are interconnected or there is a relationship (connectivity), c) Determine the solution to the problem (Eysenck, 2003).
4. On the fourth slide, students will be faced with a mission (story questions), where later the solution must involve solving problems as explained in the third slide. After each work, you will get a score and reward. This aim is to give children a passion for learning while at the same time supporting mental health in children. Then the highest student score will get a reward as a form of appreciation.

CONCLUSION

The use of application-based gamification in learning mathematics can be a potential in developing learning innovations, the use of gamification can help students learn and be able to solve problems, which is one of the mandatory indicators in learning mathematics. In addition, the use of gamification in learning can support children's mental health. The use of gamification can restore mental health, some sources indicate that games that rely on strategies can relieve stress in children.

Based on the results of the answers to three questions about gamification in mathematics learning, of course this is one of the challenges as well as opportunities for educators, innovative learning will give good results for students, problem solving skills which are one of the abilities that must be possessed by students must be focus of attention, proper use of gamification will train students' problem solving skills and improve mental health.

Systematic literature review on the use of gamification uses two types of data, namely primary and secondary, which then the data is analyzed, until the data extraction process, for future research there are still many challenges and opportunities that can be parsed and explained from the use of gamification in learning mathematics.

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ISSN: 2620-5831 (print), ISSN: 2620-4355(online)
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