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Review Paper

A Framework for Assessing the Effectiveness of Robotic Game Module on Conceptual Understanding and Earthquake Readiness Among School Students

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Abstract: The risk of earthquake disasters has caused many countries to conduct studies to develop a common strategy to deal with the disaster in order to save lives and property. It is important for all parties to be better prepared for future hazards, learning from past events which must be identified, shared and applied. This situation shows that there is a need for an earthquake education, especially for school students because they are a group that is very vulnerable to the risk of earthquake disasters at school. In this context, a deep understanding of earthquakes and readiness is an important element in the context of earthquake education. Therefore, various strategies, approaches and methods have been proposed based on 21st century technology. Learning methods based on robot games are among the methods that are able to teach students about earthquakes more effectively. Thus, this article aims to presents a conceptual framework for evaluating the effectiveness of a robotic game module on conceptual understanding and earthquake readiness among school students, based on a comprehensive review of relevant literature and theories. This study indicate that students' understanding of earthquakes and their readiness are less than satisfactory. Hence, this study is further to fill the research gaps and add a new field of knowledge through the formation of the conceptual framework in order to teach and help in preparing students that is earthquake literate.

Keywords: earthquake concept, earthquake readiness, robotic game, students.

Introduction

The phenomenon of earthquakes has the power to destroy property, kill thousands of people and completely change the structure of the earth, leaving a deep impact on many civilizations until today (Christopherson & Birkeland, 2018). Accordingly, efforts to improve understanding and readiness can be done through the school environment. Schools are institutions that have a strategic position that is able to provide facilities and skills on the early prevention of earthquake disasters (Adiyoso & Kanegae, 2013). This in turn plays a role in reducing the risk of disasters in the community and creating a community that is prepared when an earthquake disaster occurs. Meanwhile, the findings of previous studies show that school students are a group that is very vulnerable to the risk of earthquake disasters at school (Feng et al., 2021; Sapkota & Neupane, 2021; Sozen, 2019; Bikar et al., 2021a). It is not surprising that many studies say that schools are vulnerable institutions with the risk of earthquakes that house thousands of school students (Shiwaku et al., 2016; Tipler et al., 2017; Sozen, 2019).

Accordingly, a clearer understanding of the concept of earthquakes and readiness for an earthquakes is the main element that needs to be given special attention by teachers in educating students (Sozen, 2019; Toprak et al., 2018; Bikar et al., 2021b; Mutch, 2015; Zulfhikar, 2020). Scholars state that the severe and long-lasting effects of earthquakes on students can be reduced only with proper knowledge and understanding of earthquakes (Tuladhar et al., 2014; Ersoy & Kocak, 2016; Raccanellio et al., 2019; Shoji et

al., 2020; Bikar et al., 2021a). Meanwhile, several studies show that students are often victims and suffer the risk of physical injury and emotional instability for a long period when earthquakes occur in schools (Beaglehole et al., 2020; Yeon et al., 2020). Therefore, Wachtendorf et al., (2008) revealed that children have the ability to make more realistic decisions when facing an earthquake disaster only when they get enough knowledge related to earthquake disasters. This is because students have the potential to play an important role in self-recovery after an earthquake disaster (Mutch, 2015; Sozen, 2019).

Hence, many researchers suggest that game-based learning methods be used by teachers in the classroom (Feng, 2021; Mao et al., 2022; Ma et al., 2021). This needs to be highlighted to ensure students have enough knowledge and skills in the event of an earthquake disaster in the future. The use of a robot-based game module as a platform to form a learning process that not only allows students to master content related to concepts but can also improve readiness among school students. Therefore, this article discusses in depth the issues on conceptual understanding of earthquake and readiness based on analysis of literatures. Finally, this article presents a conceptual framework for assessing the effectiveness of robotic game approaches on conceptual understanding of earthquake and readiness among school students.

Methodology

The study was conducted based on library research to fulfill the objectives of the study, which is to discuss the issue of conceptual understanding and earthquakes readiness among school students, then presents a conceptual framework assessing the effectiveness of robot game module on conceptual understanding and earthquake readiness among secondary school students. The appropriate selection of secondary materials is emphasized to obtain articles and online reference materials that meet the needs of the study. Content analysis methods are used on articles from both domestic and international publications, such as journal articles, conference proceedings, thesis and book chapters discussions. All these materials are collected to increase knowledge and improve understanding of the issues and problems studied. Each selected article has been researched and coded based on three main themes (Table 1), namely understanding the concept of earthquakes, readiness for an earthquakes and robotic game approach. After that, the researcher made a critical discussion and proposed a conceptual framework for evaluating the effectiveness of a robotic game module on conceptual understanding and earthquake readiness among school students.

Table 1. Theme analysis for Assessing the Effectiveness of Robotic Game Module on Conceptual Understanding and Earthquake Readiness Among School Students

Theme	Code	Article				Total
		J	P	T	B	
Understanding the concept of earthquakes	• Theory • Students knowledge • Definition • Factors • Process • Effect	18	3	2		23
Readiness for an earthquake	• Theory • Students readiness • Before an earthquake • During an earthquake • After an	22	4	5	1	32

	earthquake					
Robotic game approach	• Theories • Earthquake topic • Robot game module • Advantages using robot in teaching and learning	16		4	2	22
Total		58	7	11	3	77

J= Journal, **P**= Proceeding, **T**= Thesis, **B**= Book chapter

Literature Review

1. Conceptual Understanding of Earthquake among School Students

Based on the literature study that have been conducted, it has been determined that students' understanding of earthquake concepts needs to be taken into account because it is important in the context of learning when the disaster occurs again. Scholars state that the severe and long-lasting effects of earthquakes on students can be reduced only with proper knowledge and understanding of earthquakes (Tuladhar et al., 2014; Ersoy & Kocak, 2016; Raccanellio et al., 2019; Bikar et al., 2021a).

In this context, students need to have enough knowledge and understanding of earthquake concepts. Concept understanding in this study means a student's mastery of earthquake concepts such as the meaning of earthquakes, scale, types, causes of earthquakes, processes and effects of earthquakes (Toprak-Dereli & Savaşcı-Açıkalın, 2018; Kayali, 2018; Henson et al., 2020; Bikar et al., 2021b). Several quantitative studies have proven that understanding earthquake concepts is important to help students acquire the right knowledge and refine knowledge about earthquakes (Simsek, 2007; Kaya & Aladag, 2017; Toprak-Dereli & Savaşcı-Açıkalın, 2018; Raccanello et al., 2019; Lownsberry & Flick, 2020).

According to concept change theory, the foundation of learning is the process of seeking information, which involves changes to a student's previous knowledge (Posner et al., 1982). This indicates that learning involves a conceptual shift (replacement or strengthening) of the concept of earthquakes, including its definition, causes, processes, and effects. To avoid misunderstandings, students must have a solid grasp of the key concepts of earthquakes in this context. This issue requires careful consideration to prevent interference with the reception of fresh information. Posner et al. (1982) reported that students were able to modify their pre-existing earthquake concepts by accepting new conceptual alterations under four teaching situations. Initially, students must be unhappy with their current understanding (dissatisfied). Secondly, they must be able to comprehend new information and then consider new notions (intelligible). Third, the novel concept must be rational (plausible). Students must acknowledge that fresh information can be used to solve issues and construct new (fruitful) knowledge.

Ironically, most students still do not understand the concept of earthquakes and end up creating learning problems. According to the major findings of the literature review, it is still an issue that students do not comprehend the concept of earthquakes (Baytiyeh & Öcal, 2016; Henson et al., 2020; Kirikkaya et al., 2011; Mehraein Nazdik et al., 2018; Mohadjer et al., 2021; Toprak-Dereli & Savaşcı-Açıkalın, 2018). The findings of these studies show that most students cannot explain the concepts of earthquakes scientifically with many alternative concepts and the steps they need to take to deal with earthquakes. In summary, these studies' findings demonstrate that scholars are paying close attention to this issues. The results of the literature review, in relation to the issue raised, reveal that students who lack a correct and thorough understanding cause misconceptions of the concept of earthquakes (Kádár & Farsang, 2017;

Toprak-Dereli & Savaşcı-Açıkalın, 2018; Dikmenli et al., 2018; Henson et al., 2020; Papp, 2020; Bikar et al., 2021b).

These misconceptions prevent meaningful learning. It is seen from a constructivist perspective, meaningful learning is built in students as a result of their sensory experiences with nature because students use this wrong understanding to interpret new experiences that hinder their ability to understand appropriately (Bikar et al., 2021c). These misconceptions occur due to various factors and one of them is because students often look for information about the topic of earthquakes through online sources which are mostly inaccurate (Lownsberry & Flick, 2020). Misconceptions cannot be completely eliminated, but can be reduced by using a variety of teaching techniques that are appropriate to the students' skill and knowledge levels. Papp (2020) states that this problem of misunderstanding has been going on for a long time and can only be overcome with critical thinking and a critical approach. In summary, the findings of the above overseas studies show that a clear understanding of the concept of earthquakes can overcome the problem of misconceptions in students.

This situation causes the urgent need to find effective strategies, approaches and methods for and understanding the concept of earthquakes is not given full attention. The results of the literature reviews mentioned indicate the necessity of assisting students in more effectively understanding the concept of earthquakes. However, there is still a lack of research to find strategies, approaches and methods to help students master the concept of earthquakes more effectively in Malaysia. Based on these views, researchers will design learning modules related to earthquake concepts that are more interactive. This researcher's statement is in line with scholars' recommendations about the use of teaching methods that are modules that integrate technology to be an effective tool for earthquake education (Winarni & Purwandi, 2018; Henson et al., 2020; Mohadjer et al., 2021).

Meanwhile, schools play a role in improving knowledge and students in dealing with earthquake disasters by providing a good environment that stimulates teaching and learning process. In addition, teachers become important individuals in imparting correct knowledge about earthquakes to students (Mutch, 2015; Bikar et al., 2021a). Mohadjer et al., (2021) stated that teachers need to take into account the factors that affect student learning, namely students' own experience of earthquakes, existing knowledge, and unfamiliarity with some learning content and pedagogical approaches, which are collaborative approaches. The findings of these studies show that this matter needs to be given special attention by teachers to ensure that students maximize their learning about earthquakes.

Thus, this situation provides a way for researchers to conduct research to fill the gap that exists related to the understanding of the concept of earthquakes and suggest learning methods that can improve students' understanding of the concept. The next research requirement will add empirical knowledge about earthquake education that focuses on students' understanding of earthquake concepts in a comprehensive manner.

2. Earthquake Readiness Among School Students

An individual's readiness for an earthquake disaster depends on the individual's level of readiness (Raccanello et al., 2020; Sozen, 2019). Accordingly, scholars emphasize the importance of education related to preparatory knowledge for individuals in order to produce resilient citizens against the threat of earthquakes. However, Raccanello et al. (2020) also stated that students are a group that needs to be prioritized by involving them actively in earthquake disaster activities because they receive severe effects when earthquakes occur.

Accordingly, many empirical studies are being conducted to examine readiness for earthquake disasters among school students. The findings of the latest studies show that students have different and unsatisfactory levels of readiness (Gurung & Khanum, 2021; Kariadi et al., 2020; Rahman, 2019; Yildiz et al., 2020). For example, Gurung & Khanum (2021) conducted a quantitative study to identify the level of readiness of students in grades 16 to 19 in Bangladesh. They discovered that out of 115 student respondents, 15 people (13%) had poor understanding of readiness, 80 people (69.6%) had medium knowledge, and 20 people (17.4%) had high knowledge. The study of Yildiz et al., (2020) also found that the level of readiness of 5th and 6th grade students in Van and Kocaeli provinces in Turkey is at a low level. Their study findings

reported that more than half of the participants in both cities did not have sufficient information about readiness plans and practices, nor about hazard readiness and adjustment measures. This is in line with the findings of previous literature studies (Baytiyeh & Öcal, 2016; Ersoy & Koçak, 2016; Henson, 2015; Tuladhar et al., 2015). However, there is still little known about the level of student readiness before, during and after more comprehensively.

Scholars agree that planning for an earthquake entails measures and preventive efforts that span three primary phases: before, during, and after an earthquake (Hosseini, 2006; Chen et al., 2012; Kendall, 2016; Cin & Digmensey, 2018; Bikar et al., 2021b). In this setting, all activities and actions must be carefully studied and systematically planned with the participation of several stakeholders. Therefore, the comprehension of acceptable measures done by school children covers three dimensions: prior to, during, and following an earthquake. According to Sözcü (2021), readiness entails knowing what to do before, during, and after an earthquake and how to utilise this knowledge. Incorporating earthquake training within the official school system will raise students' and their families' awareness.

There are several factors that contribute to the difference in students' level of readiness for earthquake disasters. One of them is because the students do not have sufficient information and proper readiness knowledge (actions to be taken) when facing an earthquake, especially at school (Kayali, 2018; Rahman, 2019; Yildiz et al., 2020). Meanwhile, the study by Bikar et al. (2021a), which was carried out in Ranau, Sabah, Malaysia, indicated that school pupils' perspectives vary because they are influenced by their experiences, cultural backgrounds, and religious beliefs. This situation directly affects their readiness when facing an earthquake disaster.

Individual conduct is often influenced by three key elements, namely attitude, subjective norms, and behavioural control, according to the theory of planned behaviour. Ajzen (1991) states that attitude components consist of personal views regarding conduct and decision evaluation. In the context of earthquake readiness, each student's belief in classroom learning will boost their motivation and readiness to support the change. In addition, subjective norm is a social factor phrase that refers to an individual's impression of social pressure from influential persons in their lives to perform or refrain from performing a particular activity (Ajzen, 2020). For instance, subjective norms are students' opinions of how their parents, peers, and teachers encourage or discourage them from engaging in a particular behaviour. In addition, the perception of behavioural control is the belief that it is difficult or simple for a person to conduct a behaviour that is influenced by his or her experiences and barriers (Ajzen, 2020). This indicates that students believe that numerous circumstances either promote or inhibit their ability to act. According to Vinnell et al. (2021), the primary predictor of a behaviour is the intention to conduct it.

The discussion of the findings of the above studies suggests the need to increase the level of student readiness when facing an earthquake. However, the studies that have been carried out are less comprehensive without studying the readiness of students from the aspects before, during and after facing the earthquake disaster. Therefore, information about the level of readiness of students as a whole to face this disaster needs to be given special attention so that it can be used as an effort to reduce the effects of earthquakes more effectively. Scholars that support this claim assert that in order for children to make sensible judgments in the event of an earthquake disaster, they constantly need adult assistance (Sözen, 2019; Yao, 2019; Wei et al., 2020). Therefore, there is an urgent need to help students improve their level of readiness for earthquake disasters so that they are better prepared to face earthquake disasters at any time (Feng et al., 2021; Papp, 2020; Toprak-Dereli & Savaşcı-Açıkalın, 2018).

All the previous research findings above also show that school students are at risk of being exposed to the effects of earthquakes. The same situation occurred in Malaysia when schoolchildren, especially teachers and students, did not prepare thoroughly to face the earthquakes that occurred in 2015 and 2018 (Zulfhikar, 2020; Bikar et al., 2021a). There is a question whether students are able to protect themselves when earthquakes happen again in the future if this matter does not need to be given full attention.

Referring to the issues and problems discussed, students should be given more comprehensive disaster readiness that includes the phases before, during and after facing an earthquake to help students have an adequate and satisfactory level of readiness (Cin & Değirmençay, 2018; Henson et al., 2020; Hosseini &

Izadkhah, 2006; Kariadi et al., 2020; Rahman, 2019). Accordingly, Feng et al. (2019) stated that students are able to prepare for earthquakes when given specific training at school. However, all exercises and activities must be taught by teachers at school.

3. Robotic Game Module

According to scholars, games are one of the most effective ways for students to acquire vital knowledge and abilities. There are studies that show the effects of game methods in improving students' knowledge and understanding in various subjects (Çoban & Göktaş, 2022; Ritchie, 2021; Manining, 2021; Saad et al., 2018). For example, Ritchie's study (2021) shows that the Wordwall game method has successfully increased the level of interest, goal orientation and achievement of 4th grade students in History.

Meanwhile, a number of similar overseas studies examine the effects of using game methods but in the context of earthquakes (Çoban & Göktaş, 2022; Feng et al., 2021; Manuhutu & Ulian, 2020; Mermer et al., 2018; Sadat et al., 2018). For example, Ismail & Akbari (2021) conducted a study examining the effects of e-learning applications while Feng et al. (2021) looked at the effects of virtual reality games among students. In addition, Winardi & Purwandari (2018) conducted a study that evaluated the learning effects of smartphone applications. In summary, the findings of all these studies show that the integration of technology is needed as a tool that helps students understand the content of a topic. In the context of Malaysia, studies on the approaches and strategies used by teachers in delivering earthquake information in the classroom have not yet developed because this earthquake phenomenon is still new. Therefore, the need to conduct a study in Malaysia to obtain evidence to support or not support the findings of previous studies discussed.

Module-based learning activities facilitate the teaching and learning process since they are split down into multiple little subtopics and methodically organised to be simple to comprehend and implement. The thorough planning and implementation of module activities ensures that teaching and learning are aligned with the desired objectives and learning outcomes (Russell, 1974; Sidek Mohd Noah & Jamaludin Ahmad, 2005). Consequently, game-based modules are appropriate for use in the earthquake teaching and learning process.

The discussion of all previous research findings above shows that the game method is an effective method for earthquake education, because it displays earthquake information in a more interactive way (Feng et al., 2020; Feng et al., 2021; Manining, 2021; Rabe et a1., 2022). This in turn allows students to understand the concept of earthquake lesson content for a longer period of time. However, most of the studies discussed focused on students' understanding in the context of preparatory knowledge (actions to be taken) when facing an earthquake and less focus on the concepts of earthquakes (such as the meaning of earthquakes, scale, types, causes of earthquakes, earthquake processes and effects) (Lownsberry & Flick, 2020; Toprak-Dereli & Savaşcı-Açıkalın, 2018). In fact, most of the studies above only focused on interventions to improve dimensional readiness during and after facing an earthquake. On the other hand, scholars agree that any form of program and intervention to ensure that individuals receive training and master the right skills needs to involve three main phases before, during, and after the earthquake, as well as how to implement them (Bikar et al., 2021b; Hosseini & Izadkhah, 2006; Subedi et al., 2020; Sözcü, 2021; Yao, 2019).

As a result of the technological revolution of the 21st century, one of the most advanced teaching systems that may be employed in the teaching and learning process is robots (Parra-González et al., 2021; Amin et al., 2021). Accordingly, robots are an alternative technology that can be used as teaching aids that facilitate the transfer of the content of a topic more effectively (Sanchez et al., 2019). This is because the interaction of robots in the process of teaching and learning games can increase students' intrinsic motivation, improve critical thinking skills problem solving and student metacognition (Bikar et al., 2020), as well as their ability to learn things more easily complex (Gorakhnath & Padmanabhan, 2017; Parra-González et al., 2021).

The construction of modules in the teaching and learning process of earthquake is organised and planned so as to allow for the exchange of incorrect information and the improvement of students'

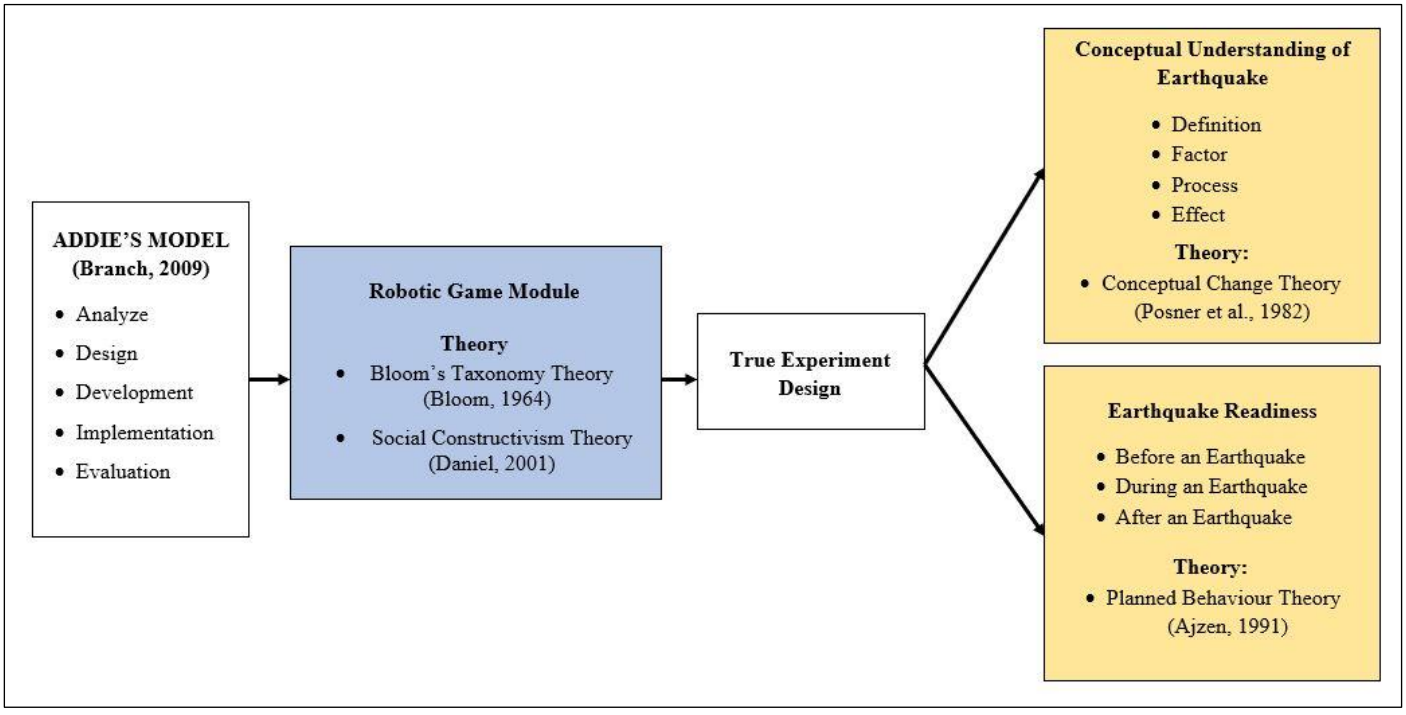
understanding of earthquake concepts and appropriate readiness before, during, and after an earthquake. The inclusion of game-based robotics can entice students to effectively grasp the learning content (Parra-González et al., 2021; Amin et al., 2022), which can improve the effectiveness of the module. The proposed set of activities attempts to boost motivation and comprehension of particular goals. This programme provides teachers with information that enables them to teach more effectively and methodically.

However, studies related to robot-based game methods on the understanding of the concept of earthquakes among students are still less conducted abroad and in Malaysia. Therefore, the learning process based on the robot-based game module proposed by the researcher as a step to improve students' understanding by mastering the content of learning earthquake science further increases the motivation of students to continue to remain focused in the context of active learning. In addition to this, the use of this game robot is one of the ways highlighted to improve more practical and effective readiness skills among students facing this disaster in the future.

Discussion

A review of the literature reveals the importance of assisting students in better understanding the concept of earthquakes and boosting their level of readiness when confronted with an earthquake. Therefore, the use of robotic game approach in teaching enhances students' engagement, motivation, as well as their ability to learn things more easily (Gorakhnath & Padmanabhan, 2017; Bikar, 2020; Parra-González et al., 2021; Amin et al., 2021). However, less of these studies focus on assessing the effectiveness of robotic game module on conceptual understanding and earthquake readiness among school students. Thus, this study will be carried out to fill the gaps in the research based on the conceptual framework depicted in Figure 1.

Figure 1. Conceptual Framework



The ADDIE model, as shown in Figure 1, serves as the fundamental reference in the development of a robotic game module. ADDIE stands for Analyze, Design, Develop, Implement, and Evaluate (Rossett, 1987; 8-9). All planned activities in ADDIE focus on assisting students to gain knowledge across numerous learning areas (Branch, 2009; 3). This robotic game module includes several systematic teaching and learning units based on specific topics that allow students to learn important earthquake concepts and better

prepare for earthquakes. Simultaneously, experimental methods were used to test the effectiveness of the robotic game module on students' understanding of concepts and readiness for earthquakes.

The robotic game module is the independent variable. The researcher will use a robotic game module to identify its effectiveness against two dependent variables that exist in this study, namely the understanding of the concept of earthquakes and readiness for earthquakes among high school students. The module is a game-shaped module and as a new approach to convey earthquake knowledge to high school students. In this context, Social Constructivism Theory assists in comprehending the progression of student learning. In addition, Bloom's Taxonomy is utilised to arrange and organise module activities based on the cognitive level of the students, hence optimising the quality of learning outcomes. This is for teachers to be able to assess objectives connected to instruction and learning.

In addition, there are two independent variables that exist in this study. First, is the understanding of the earthquake concept that covers four main dimensions. The first dimension is the definition of an earthquake. The second dimension is the factor of an earthquake. The third dimension is the process of earthquake and the fourth dimension is the impact of an earthquake disaster. The Conceptual Change Theory is utilised as a guide and primary reference by researchers to plan and structure instruction so as to adhere to this theory's essence, so enabling students to acquire and comprehend the fundamental concepts of earthquakes more successfully.

The dependent variable, which is readiness for an earthquake, is divided into three main dimensions, which are readiness before the earthquake, readiness during the earthquake and readiness after the earthquake. These two independent variables are affected by the independent variable that is robotic game module when this study is carried out later. This study is likewise guided by the Theory of Planned Behavior since it examines students' level of readiness before, during, and after an earthquake event.

Implication of Study

The implication of this study provides new insights related to the level of understanding of the earthquake concept and readiness for this disaster among school students. This study is further to fill the research gap that exists based on the discussion of the findings of the literature study. Throughout the formation of the conceptual framework, the researcher will propose a robot game module method to teach students on earthquake topics and readiness involving dimensions before, during and after an earthquake through authentic experimental design, especially among school students who are at risk of earthquake threats. This study will offer a new field of knowledge to the subject of earthquake catastrophe education in order to construct and prepare an earthquake-literate society.

Conclusion

The findings of prior research indicate that students are a particularly sensitive group to the danger of earthquake-related disasters at school. Moreover, the results of the cited literature evaluations highlight the need to aid students in better comprehending the concept and preparing for earthquakes. However, based on the discussed literature, the students' level of comprehension of the notion of earthquakes must be enhanced because it is still unsatisfactory. In addition, teachers play a crucial role in providing students with accurate earthquake knowledge. This issue should be emphasised in order to concentrate on teaching and learning. To solve this issue, a number of researchers recommend that teachers implement robot-based game-based learning techniques. Thus, there is a significant chance of evaluating the efficiency of the robotic game module on conceptual comprehension and earthquake preparedness among school students.

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