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"Development and Validation of "Hazard O'Clock": A Home Hazard and Disaster Awareness Game"

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ABSTRACT: The Philippines is the fourth most disaster-prone country in the world due to its location in the Pacific Ring of Fire and Pacific Typhoon Belt. When it comes to these disasters, children below the age of 18 are considered to be among the most vulnerable. This study aimed to develop a mobile game about Disaster Risk Reduction and Management (DRRM) in the home setting that can be used as a teaching aid for children. The information integrated into the game was from different resources made by various government agencies. The Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model was used in the development of the game, and game development educators and STEM educators evaluated it. Using a 5-point Likert scale survey, the game's quality and appropriateness were evaluated for the following categories: Instructional Content, Functional Suitability, Performance Efficiency, and Usability. For each category, the mean score ratings were 4.43, 4.43, 4.80, and 4.60 respectively. Overall, the game received a rating of 4.52 indicating that it is Very Appropriate for its purpose. The research findings have shown that the game, Hazard O'Clock, could be used as a teaching aid for DRRM.

KEYWORDS: disaster awareness; mobile serious game; game development; ADDIE model; game-initiated learning

INTRODUCTION

The Philippines is considered the fourth most disaster-prone country in the world due to its location in the Pacific Ring of Fire and the Pacific Typhoon Belt (Asian Disaster Reduction Center [ADRC], 2020; United Nations, 2020; United Nations Office for Disaster Risk Reduction [UNDRR], 2010). This circumstance causes the country to experience strong earthquakes and an average of 19 to 20 typhoons annually (Cayanan et al., 2011, as stated by Algo et al., 2016). According to Mapa (2020), the Philippines had incurred a total of 463 billion pesos worth of damages along with the deaths of 12,097 people due to natural disasters from 2010-2019.

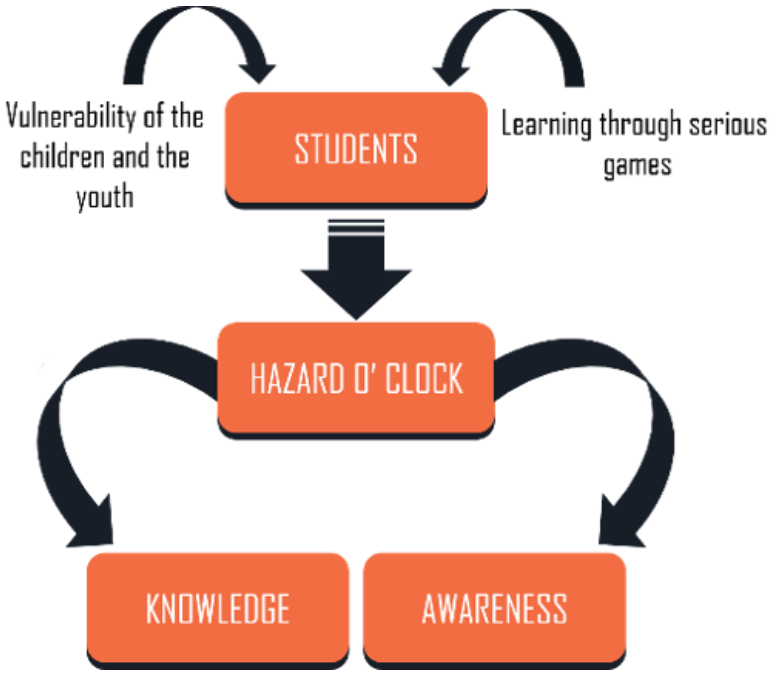
The Centre for Research on the Epidemiology of Disaster (CRED, 2006, as cited by Sawada, 2007) defined disasters as events that can cause great damage and overwhelm local coping capacity. This includes both natural and man-made events. Most of the country's population lives in urbanized high-risk areas, where buildings are often done without expert opinion, thus leading to structures that are defective and susceptible to man-made hazards such as fire (Joyas et al., 2019; World Bank, 2014). In 2018, the Bureau of Fire Protection (BFP) reported 72,318 recorded cases of fire incidents in the country from the years 2012 to 2016.

In line with the effects of disasters, the National Disaster Risk Reduction and Management Plan or NDRRMP (National Disaster Risk Reduction and Management Council [NDRRMC], 2010), have set plans and policies that were put into place aiming to strengthen community infrastructure and housing to minimize risks and hazards in both commercial and residential areas. It also aims to educate people, especially children, about Disaster Risk Reduction and Management (DRRM) to improve disaster information dissemination.

Following the designed paradigm (Figure 1), this study aims to develop a mobile game that integrates natural and man-made hazards concepts. The game will then be used to educate children and raise their awareness about the concepts of DRRM in the home setting.

Figure 1

Paradigm



Consequently, the focus of the study is to determine: if the game's learning content were accurate and relevant (Instructional Content), and suitable for students of age under 18 (Functional Suitability); whether the game runs appropriately without bugs (Performance Efficiency); and whether the game was able to achieve appropriate ratings in system intuitiveness and visual aesthetics (Usability).

Children below the age of 18 are among the most vulnerable when it comes to disaster scenarios (Back et al., 2009; UNDRR, 2011; Peek, 2008). According to Ciotonne et al. in 2006, as cited by Allen et al. in 2007, children have the highest mortality rate during disastrous events. Penrose and Takaki (2006, as cited by Peek 2008) stated that there is an estimate of 66.5 million children affected by disasters yearly. This number is expected to rise to 175 million children annually by 2020 (Save the Children UK, 2007, as cited by Peek, 2008). Clerveaux and Spence (2011, as cited by Dela Rosa et al., 2020) mentioned in their study that this vulnerability could be reduced by properly educating them about disaster concepts and disaster mitigation.

In a study by Tsai et al. (2015), game-initiated learning (GIL) was shown to improve the motivation and ability of the students to focus on studying topics related to DRRM. This is said to be due to the pleasure induced to students while they were playing.

It was also shown that games catalyzed for the students to start their discussions about the topics discussed in the game afterward. Consistent with this, mobile phone applications have been proven to be effective media in delivering learning content to students (Drigas & Angelidakis, 2017; Valk et al., 2010).

These applications can be in the form of Serious Games (SG) that can help learners to acquire knowledge through the integration of entertainment in education (Gee, 2003, Wahyudin & Hasegawa, 2017). A 2017 study shows that Mobile Serious Games (MSG) are engaging and are acceptable media for teaching children (Huang et al., 2017). Additionally, Sanchez and Olivares (2011, as cited by Koutromanos & Avraamidou, 2014) used MSG-based practices that have aided in the improvement of the understanding and problem-solving skills of high school students.

In a study by Tsai, et al. (2014), an SG about city flood disasters was used as alternative teaching material for high school students in Taiwan. The results show that the SG developed helped students promote city flood disaster awareness. They also concluded that SGs focusing on disasters could be used as teaching aids to help engage students to learn more about disaster prevention.

Similarly, in a related thesis conducted by Barreto (2014), an SG was used to train and teach elementary students about Disaster Risk and Management (DRM) procedures before, during, and after an earthquake. The results show that the game was able to reinforce the students' prior knowledge about the topic while also helping them learn new concepts. As concluded in their study, the SG successfully increased the students' understanding of earthquake preparedness and the related DRM principles.

However, although these SGs are effective tools for spreading information and awareness, only a few of these SG studies are focused on spreading disaster awareness (Gampell & Gaillard, 2016). Furthermore, most Filipinos are still unprepared for most hazards

and continually underestimate the consequences of frequently occurring disasters. (Bollettino et al., 2016; Bollettino et al. 2018).

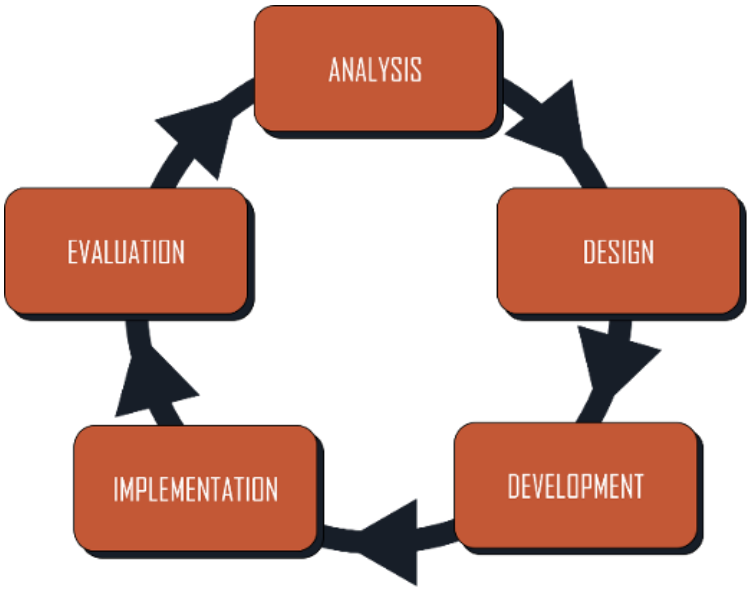
The mobile game, Hazard O'Clock, was then developed to be used to promote disaster awareness and DRRM to children below the age of 18. It was also designed to be used by educators to teach the students about the subject DRRM in an interactive manner.

However, the disasters that were mentioned in the game are limited to those frequently experienced in the country. Also, the hazards and scenarios that were tackled in the game are restricted to those observed inside the household setup. Hazard O'Clock will only be available for android devices as a mobile application.

METHODOLOGY

Figure 2

ADDIE Model



This study employed a Descriptive Developmental Research Design. The ADDIE (Analysis, Design, Development, Implementation, and Evaluation) Model as seen in Figure 2 was adopted in the development of the mobile game Hazard O'Clock.

This model served as a guide throughout the study. Through this model, the researchers could make further improvements during the game's development. Revisions were made in every stage of development and were subjected to the evaluation of the

study's advisers. The comments and suggestions that the advisers made were then incorporated into the game.

Analysis

The concept of DRRM in the household setup was assessed through the review of related literature. The game emphasizes the effects of frequently occurring disasters in the country, such as typhoons, flooding, fire incidents, and earthquake disasters.

Table 1

Government Infographics Used as References

Infographics used	Source
DILG - Fire Safety Tips	Department of Interior and Local Government Philippines [@DILGPhilippines]. (2019, March 12). Fire Safety Tips Make sure your house is always safe from all kinds of destructive fires. Take note of these safety measures from [Tweet]. Twitter. https://twitter.com/DILGPhilippines/status/1105296328442077184?s=20
OCD - Disaster Preparedness Guide (Fire, Flood, Earthquake, Go bags)	Office of Civil Defense [OCD]. (n.d.). Disaster Preparedness Guide Infographics. Retrieved from https://mmda.gov.ph/20-faq/288-disaster-awareness-faq.html
BFP Tarlac City – Fire Safety Tips at Home	Bureau of Fire Protection (BFP) – Tarlac City (2020). Fire Safety Tips. Retrieved from https://www.facebook.com/181650662434809/posts/think-fire-safety-fsed-bfp-region-iiifiresafetytipsduringmgcq/639402679992936/
PHIVOLCS – JICA House Safety Checklist	Philippine Institute of Volcanology and Seismology [PHIVOLCS] et al. (n.d). How Safe is My House? Retrieved from https://www.phivolcs.dost.gov.ph/vault/pdf/Publication_Earthquake%20Preparedness/Flyer-How-Safe-Is-Your-House.pdf
PAGASA Flood Learning Tools	Philippine Atmospheric Geophysical Astronomical Services Administration [PAG ASA]. (n.d.) Flood Learning Tools. Retrieved from http://www.pagasa.dost.gov.ph/learning-tools/floods

The topics focused on and used were based on DRRM infographics made by different government agencies in the Philippines which can be seen in Table 1. These consist of disaster preparedness infographics made by the Department of Interior and Local Government (DILG), Office of Civil Defense (OCD), BFP, and Philippine Institute of Volcanology and Seismology (PHIVOLCS); along with learning tools from Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAG-ASA).

Moreover, due to having children and youth aged 17 and below as the target audience of the game, appropriate adjustments were made to enhance the game's level of engagement. This includes planning for the art style and finding suitable background music for the game.

Design and Development

In this stage, findings from the analysis were used as a basis for the content of the game. A storyboard was created from all the materials that were gathered to facilitate the game's flow. Integrated into this storyboard are mini games that focus on helping the player identify and differentiate the concepts of hazards and disaster. These are presented in a quiz-type format. Along with this, interactive mini-game formats were also included in between the lessons. This can help the player learn and understand how to prepare for and mitigate hazards and disasters. Figures 3 to 5 present the five mini-games developed and arranged as sequenced in the game.

Figure 3

Game 1: Hazard VS Disaster

The first mini game (Figure 3) is entitled "Hazard VS Disaster." This tests the understanding of the players regarding the basic concept and difference between hazardous and disastrous events. Five (5) situations were presented in the game, and the players had to choose if the given scenario was a hazard or a disaster.

Figure 4

Game 2: Concepts of Disaster

As for the 2nd mini game is entitled "Concepts of Disaster" (Figure 4). Here the players are tasked to identify whether each scenario represents one of the three concepts of disaster: capacity, exposure, or vulnerability. Similar to the previous game, there are also five (5) scenarios presented in this game.

Figure 5

Game 3: Add to Cart

Figure 5 shows the 3rd mini game, "Add to Cart," through the aid of the given description of each item, the players must choose nine items that are necessary for the survival of a family during an emergency scenario. Mixed in the list are non-essential things that give players some difficulty.

Figure 6

Game 4: Fault Finder

"Fault Finder" is the 4th mini game (Figure 6) included in Hazard O'Clock. This game is based on an application developed by PHILVOLCS bearing the same title. With this, the players are tasked to select the four (4) barangays within a certain buffer zone from a nearby fault line.

Figure 7

Game 5: Hazard Hunt

As for the final mini game (Figure 7), “Hazard Hunt” the players were tasked to find different hazards within the household. With the house having four different areas, the players are tasked to find three hazards in each area. To help the players, silhouettes of the hazard in each area are provided.

To enhance the player’s experience throughout the game, sound and vibration feedback are provided to indicate whether the player got the correct or wrong answer.

Additionally, at the end of the game, the players are provided options so that they can (1) play the game again from the beginning, (2) choose from the five mini games included to play again, or (3) exit the application.

Game models and assets were created using Blender 3D, a free 3D modeling software. While Sketch-Up was used to design the buildings seen in the game. On the other hand, Unity was used for the compilation of all the game assets and the animations visible while playing the game. It was also used to write and debug the code that runs the game.

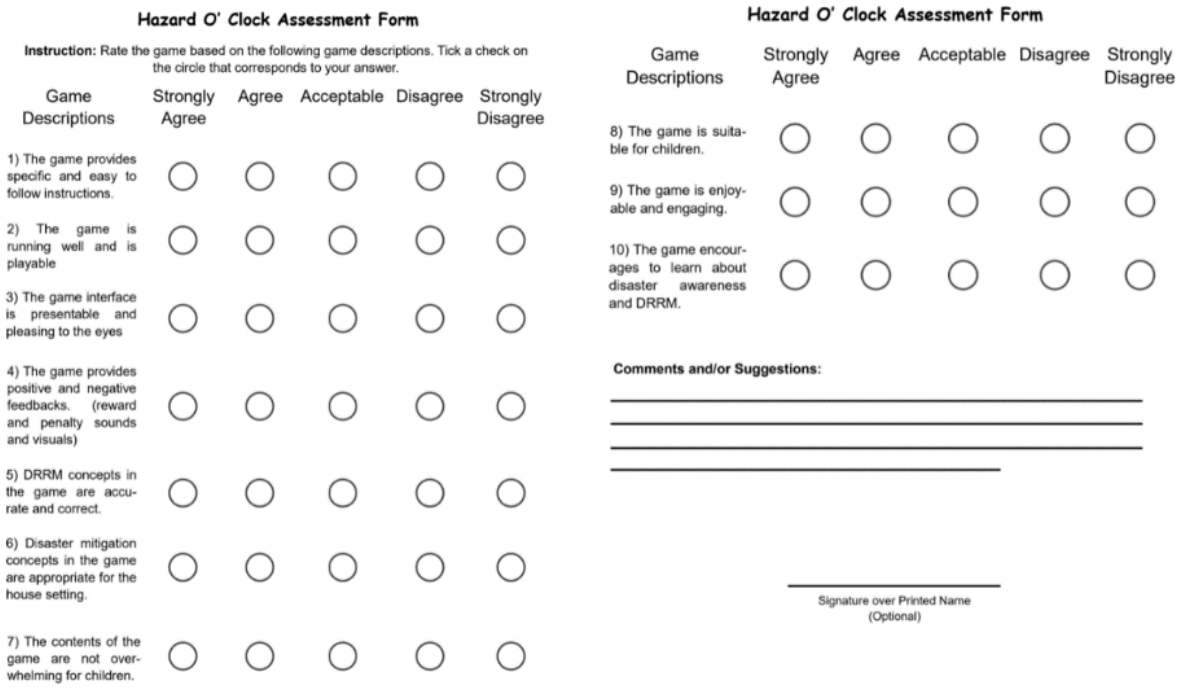
Implementation and Evaluation

Hazard O’Clock was first formally implemented to 5 game development educators and 5 STEM educators, which consisted of 4 sciences major teachers and a DRRM coordinator, who were chosen through purposive sampling. Communication letters were sent via email to the contact persons in their respective institutions. Physical evaluation forms and emails include a "To the Respondents" page which informs the game evaluators of the purpose of the research and guarantees confidentiality of their information. Before the evaluation, the respondents were briefed on how their responses will be used exclusively for the study.

They evaluated the game by accomplishing a survey questionnaire in the form of a five-point Likert Scale which can be seen in Figure 8. As the study was done during lockdown, a separate digital questionnaire was also provided to some evaluators to follow strict quarantine protocols.

Figure 8

Hazard O'Clock Assessment Form



Hazard O' Clock Assessment Form

Instruction: Rate the game based on the following game descriptions. Tick a check on the circle that corresponds to your answer.

Game Descriptions	Strongly Agree	Agree	Acceptable	Disagree	Strongly Disagree
1) The game provides specific and easy to follow instructions.	○	○	○	○	○
2) The game is running well and is playable	○	○	○	○	○
3) The game interface is presentable and pleasing to the eyes	○	○	○	○	○
4) The game provides positive and negative feedbacks. (reward and penalty sounds and visuals)	○	○	○	○	○
5) DRRM concepts in the game are accurate and correct.	○	○	○	○	○
6) Disaster mitigation concepts in the game are appropriate for the house setting.	○	○	○	○	○
7) The contents of the game are not overwhelming for children.	○	○	○	○	○

Hazard O' Clock Assessment Form

Game Descriptions	Strongly Agree	Agree	Acceptable	Disagree	Strongly Disagree
8) The game is suitable for children.	○	○	○	○	○
9) The game is enjoyable and engaging.	○	○	○	○	○
10) The game encourages to learn about disaster awareness and DRRM.	○	○	○	○	○

Comments and/or Suggestions:

_____

_____

_____

_____

_____

Signature over Printed Name
(Optional)

The five-point Likert scale has the options: Strongly Agree (5), Agree (4), Acceptable (3), Disagree (2), and Strongly Disagree (1). The form has 10 game descriptions that the evaluators may agree or disagree on using the scale.

The game was evaluated and validated for the following qualities: Instructional Content, Functional Suitability, Performance Efficiency, and Usability, which are based on ISO 25010 or the Software Product Quality Model (ISO, 2011). Additionally, a comments and suggestion section was added to allow the evaluators to give their subjective feedback and insights. The scores that the educators on the Likert scale gave were tallied. The mean and standard deviation of all the scores the experts gave was used to conclude the game's quality and appropriateness.

Table 2

Interpretation of the mean of the scores given by the evaluators

MEAN	INTERPRETATION
4.21 - 5.00	Very Appropriate
3.41 - 4.20	Appropriate
2.61 - 3.40	Acceptable
1.81 - 2.60	Inappropriate
1.00 - 1.80	Very Inappropriate

The interpretations of the mean of the scores given by the evaluators are presented in table 2. This was based on the 4-point Likert scale interpretation table by Lawsin and Garcia (2018, as cited by Dela Rosa et al., 2020); however, according to a study conducted by Chyung et al. (2017), a 5-point Likert scale is more appropriate to use with respondents who are familiar and knowledgeable to the topic; thus, the addition of a midpoint.

RESULTS AND DISCUSSION

The raw data gathered through the evaluation of the different educators were used to compute the mean score and standard deviation of the ratings for each characteristic under the four-game quality categories. The results were used to determine the appropriateness of the developed mobile game Hazard O'Clock as a learning aid in teaching the subject DRRM to the target audience.

Table 3

Mean, Standard Deviation, and Mean Score Interpretation for Instructional Content and its Components

	MEAN	STANDARD DEVIATION	INTERPRETATION
Instructional Content	4.43	0.7279	Very Appropriate
Correctness of content	4.80	0.4216	Very Appropriate
Relevance of Instructional Events	4.60	0.5164	Very Appropriate
Engagement	3.90	0.8756	Appropriate

Table 3 shows the mean and standard deviation of the characteristics under the category Instructional Content. The characteristics Correctness of Content, Relevance of Instructional Events, and Engagement received the following mean scores respectively: 4.80, 4.60, and 3.90; and standard deviation: 0.4216, 0.5164, and 0.8756, respectively. This means that the information and situations presented in the game are all appropriate and relevant to the subject of DRRM. The small standard deviations also show that the values obtained from the evaluations are not that far from each other, thus minimizing random errors.

However, of all the components, only Engagement received an Appropriate rating. Although the result is still above acceptable, the evaluators suggested improvements such as including additional images and other graphic displays in the game to maximize the Engagement of the users.

Overall, the game's Instructional Content received a mean score rating of 4.43 and a standard deviation of 0.7279, which corresponds to the interpretation Very Appropriate. These ratings imply that the evaluators found the teaching content in the game to be accurate as a teaching aid for the concepts that it covers which include concept of hazards and disasters, identification of hazards, go bag and emergency items, and the use of PHIVOLCS FaultFinder.

Table 4

Mean, Standard Deviation, and Mean Score Interpretation for Functional Suitability and its Components

	MEAN	STANDARD DEVIATION	INTERPRETATION
Functional Suitability	4.43	0.5683	Very Appropriate
Functional Appropriateness	4.70	0.4830	Very Appropriate
Functional Correctness	4.30	0.5712	Very Appropriate

The mean and standard deviation of each characteristic under the category Functional Suitability is shown in table 4. The Functional characteristics Appropriateness and Functional Correctness received the mean scores: 4.70 and 4.30, respectively, which correspond to the interpretation of Very Appropriate. Their respective standard deviations are 0.4830 and 0.5712. This shows that the scores provided by the evaluators are not that different from each other, indicating that random errors are minimized.

Overall, the game's Functional Suitability has a standard deviation of 0.5683 and a mean score rating of 4.43, which corresponds to the interpretation of Very Appropriate. This indicates that the evaluators see the game as a suitable and effective teaching aid and that it will not overwhelm its intended players.

Table 5

Mean, Standard Deviation, and Mean Score Interpretation for Performance Efficiency and its Components

	MEAN	STANDARD DEVIATION	INTERPRETATION
Performance Efficiency	4.80	0.4216	Very Appropriate
Resource Utilization	4.80	0.4216	Very Appropriate

Table 5 presents the mean and standard deviation of the characteristic under the category Performance Efficiency. Since this category is defined only by the characteristic Resource Utilization, the mean score and standard deviation for this are the same as the ones for the characteristic. Thus, the game's Performance Efficiency obtained a standard deviation of 0.4216 and a mean score of 4.80, corresponding to a Very Appropriate interpretation. The low standard deviation also implies the possibility of random errors in the study. This rating indicates that the game is running well and all assets are working as intended. The evaluators did not find or encounter any bugs that may hinder the players' learning experience.

Table 6

Mean, Standard Deviation, and Mean Score Interpretation for Usability and its Components

	MEAN	STANDARD DEVIATION	INTERPRETATION
Usability	4.60	0.6215	Very Appropriate
Operability	4.70	0.4830	Very Appropriate
Learnability	4.50	0.8498	Very Appropriate
User Interface aesthetics	4.60	0.5164	Very Appropriate

Finally, the mean and standard deviation of the characteristics under the category Usability is shown in table 6. The characteristics Operability, Learnability, and User Interface Aesthetics received the following mean scores respectively: 4.70, 4.50, and 4.60, which all correspond to the interpretation Very Appropriate; while the standard deviations are 0.4830, 0.8498, and 0.5164, respectively, which indicates a small possibility of having random errors. Overall, the game's Usability has a standard deviation of 0.6215 and garnered a mean score rating of 4.60, which corresponds to the interpretation of Very Appropriate.

This shows that the evaluators found the game's mechanics easy to understand and easy to play. With this, the players can focus on the game content and not consume more time trying to understand how to play the game. The evaluators have also agreed that the game is visually appealing and is fit for students of the intended age group.

Table 7

The Mean, Standard Deviation, and Mean Score Interpretation for Each Category

CATEGORY	MEAN	STANDARD DEVIATION	INTERPRETATION
Instructional Content	4.43	0.7279	Very Appropriate
Functional Suitability	4.43	0.5683	Very Appropriate
Performance Efficiency	4.80	0.4216	Very Appropriate
Usability	4.60	0.6215	Very Appropriate
Overall	**4.52**	**0.6273**	**Very Appropriate**

In table 7, a summary of the mean score ratings and standard deviations of the game for each category of game quality were presented. All the mean scores for each category correspond to an interpretation of Very Appropriate. Overall, the game's overall rating is 4.52, with a standard deviation of 0.6273 and an interpretation of Very Appropriate. The standard deviation for all game quality ratings and the overall rating is less than one, indicating that the ratings are close to the means. These values imply that the mobile game is well developed.

In congruence to a study conducted by Tsai et al. (2014), games that are well developed can be a suitable material to promote students' motivation in learning about DRRM.

CONCLUSION AND RECOMMENDATION

Conclusion

The ratings that the game, Hazard O' Clock, received from the 5 game development educators and five science educators validate its appropriateness as a teaching aid. The game's Instructional Content is accurate and presents pertinent situations that the student can easily understand. With its Functional Suitability having a high mean score, it's

guaranteed that the game's content is not overwhelming and that it is also appropriate for its target audience.

The gathered data has also established that the game's strong points are its Performance Efficiency and Usability. The high ratings for these characteristics indicate that the game has no hindering bugs that might interfere with the user's playing time. This also indicates that Hazard O'Clock is fluid and easy to play which helps the student to better focus on the presented Instructional Content.

All of its game qualities accomplished scores close to the highest rating, 5, and are considered very appropriate for its purpose. As a whole, Hazard O'Clock received an overall rating of 4.52 or Very Appropriate, indicating that the game can be used as a supplementary teaching aid that can help teach and promote disaster concepts and DRRM to students below the age of 18.

Recommendations

Given the game's high ratings in all game quality categories and its high overall rating, it is recommended to conduct a pretest and posttest study directed to students to determine the efficacy of Hazard O' Clock as supplementary teaching material. With this recommendation, it is preferable to have students in high school as participants. It is also recommended to program the game so that the user's data can be stored. This way, the players wouldn't need to play the game from the beginning every time they open the application.

Also, as stated by the evaluators, adding more images and other visual materials is recommended to enhance the game's quality. The evaluators also recommended including additional features such as: making the tips in the loading screen a part of another mini-game, adding a hint feature, and adding a back navigation feature so that players can re-read information that they may have missed.

REFERENCES

Alcayna, T., Bollettino, V., Dy, P., & Vinck, P. (2016). Resilience and disaster trends in the Philippines: Opportunities foional and Local Capacity Building. PLoS Currents Disasters. https://doi.org/10.1371/currents.dis.4a0bc960866e53bd6357ac135d740846

Allen, G., Parrillo, S., Will, J., & Mohr, J. (2007). Principles of Disaster Planning for the Pediatric Population. *Prehospital And Disaster Medicine*, *22*(6), 537-540. https://doi.org/10.1017/s1049023x00005392

Asian Disaster Reduction Center [ADRC]. (2020). Information on Disaster Risk Reduction of the Member Countries|Philippines. *Adrc.asia.* Retrieved 19 November 2020, from https://www.adrc.asia/nationinformation.php?NationCode=608&Lang=en.

Back, E., Cameron, C., & Tanner, T. (2009). Children and Disaster Risk Reduction: Taking Stock and Moving Forward. *Children In A Changing Climate*. Retrieved 6 December 2020, from https://www.researchgate.net/publication/265184281_Children_and_Disaster_Risk_Reduction_Taking_Stock_and_Moving_Forward.

Barreto, P. (2014). *Treme-treme - A serious game to teach children earthquake preparedness* (Masters). Tecnico Lisboa. Retrieved 29 November 2020 from https://fenix.tecnico.ulisboa.pt/downloadFile/563345090413387/dissertacao.pdf

Bolletino, V., Alcayna, T., Enriquez, K., & Vinck, P. (2018). Perceptions of Disaster Resilience and Preparedness in the Philippines. *Harvard Humanitarian Initiative*. Retrieved 20 November 2020, from https://hhi.harvard.edu/sites/default/files/publications/prc-phillippine-report-final_0.pdf.

Bureau of Fire Protection [BFP]. (2018) BFP Nationwide Fire Incidents Statistics for CY 2012-2016. Data.gov.ph. https://data.gov.ph/?q=dataset/bfp-nationwide-fire-incidents-statistics-cy-2012-201

6/resource/c7c4ab26-87ad-4702-b1b3#%7Bview-grid:%7BcolumnsWidth:[%7Bcolumn:!YEAR,width:94%7D,%7Bcolumn:!INCIDENTS,width:277%7D]%7D%7D

Chyung, S., Roberts, K., Swanson, I., & Hankinson, A. (2017). Evidence-Based Survey Design: The Use of a Midpoint on the Likert Scale. *Performance Improvement*, *56*(10), 15-23. https://doi.org/10.1002/pfi.21727

Dela Rosa, P., Villar, J., Ancheta, M., Cumbe, M., De Vera, R., (2020). Laging Handa: Development of a Mobile Game on Hydrometeorological and Geological Hazard Awareness [Unpublished Manuscript]. Caloocan City Science High School

Drigas, A., & Angelidakis, P. (2017). Mobile Applications within Education: An Overview of Application Paradigms in Specific Categories. *International Journal Of Interactive Mobile Technologies (Ijim)*, 11(4), p.17. Retrieved 27 November 2020 from doi: 10.3991/ijim.v11i4.6589

Gampell, A., & Gaillard, J. (2016). Stop Disasters 2.0: Video Games as Tools for Disaster Risk Reduction. *International Journal Of Mass Emergencies And Disasters*, 34(2), pp. 282-316. Retrieved 3 December 2020 from https://www.researchgate.net/publication/316010486_Stop_Disasters_20_Video_Games_as_Tools_for_Disaster_Risk_Reduction

Huang, Y., Chang, D., & Wu, B. (2017). Mobile Game-Based Learning with a Mobile App: Motivational Effects and Learning Performance. *Journal Of Advanced Computational Intelligence And Intelligent Informatics*, 21(6), pp. 963-970. Retrieved 17 November 2020 from https://doi.org/10.20965/jaciii.2017.p0963

International Standards Organization [ISO] (2011). ISO 25010: System and Software Quality. Retrieved from ISO 25010 (iso25000.com)

Joyas, L., de Castro, L., & Moling, J. (2019). A Market Study Of Residential Retrofit Financing. *BuildChange*. Retrieved from

https://buildchange.org/app/uploads/2019/01/Disaster_Resiliency_in_Housing_in_the_Philippines-Web.pdf

Koutromanos, G., & Avraamidou, L. (2014). The use of mobile games in formal and informal learning environments: a review of the literature. *Educational Media International,* 51(1), 49–65. Retrieved 5 December 2020 from https://www.researchgate.net/publication/260564345_The_use_of_mobile_games_in_formal_and_informal_learning_environments_A_review_of_the_literature

Mapa, D. (2020) Damages Due to Natural Extreme Events and Disasters Amounted to PhP 463 Billion, *Philippine Statistics Authority. Psa.gov.ph.* Retrieved 17 November 2020, from https://psa.gov.ph/content/damages-due-natural-extreme-events-and-disasters-amounted-php-463-billion.

National Disaster Risk Reduction and Management Council [NDRRMC]. (2010). National Disaster Risk Reduction and Management Plan 2011-2028. Retrieved 19, November 2020 from https://ndrrmc.gov.ph/attachments/article/41/NDRRM_Plan_2011-2028.pdf

Peek, L. (2008). Children and Disasters: Understanding Vulnerability, Developing Capacities, and Promoting Resilience — An Introduction. *Children, Youth and Environments, 18*(1), 1-29. Retrieved February 23, 2021, from http://www.jstor.org/stable/10.7721/chilyoutenvi.18.1.0001

Sawada, Y. (2007). The impact of natural and manmade disasters on household welfare. *Agricultural Economics,* 37, pp. 59-73. Retrieved 16 November 2020 from https://doi.org/10.1111/j.1574-0862.2007.00235.x

Tarman, B., Kilinc, E., & Aydin, H. (2019). Barriers to the effective use of technology integration in social studies education. *Contemporary Issues in Technology and Teacher Education*, 19(4). Retrieved 19 November 2020, from

https://citejournal.org/volume-19/issue-4-19/social-studies/barriers-to-the-effective-use-of-technology-integration-in-social-studies-education

Tsai, M., Wen, M., Chang, Y., & Kang, S. (2014). Game-based education for disaster prevention. *AI & SOCIETY*, 30(4), pp. 463-475. Retrieved 1 December 2020 from https://www.researchgate.net/publication/265787653_Game-Based_Education_for_Disaster_Prevention

Tsai, M.-H., Chang, Y.-L., Kao, C., & Kang, S.-C. (2015). The effectiveness of a flood protection computer game for disaster education. Visualization in Engineering, 3(1). https://doi.org/10.1186/s40327-015-0021-7

United Nations Office on Disaster Risk Reduction [UNDRR]. (2010) Synthesis Report on Ten ASEAN Countries Disaster Risks Assessment. p. 42. Retrieved 20 November 2020, from https://www.unisdr.org/files/18872_asean.pdf

United Nations Office for Disaster Risk Reduction [UNDRR]. (2011). Children and Disasters: Building Resilience Through Education. Retrieved 20 November 2020, from https://www.unisdr.org/files/24583_childrenanddisastersbuildingresilie.pdf

United Nations Office on Disaster Risk Reduction [UNDRR]. (2019). Disaster Risk Reduction in the Philippines. Retrieved 20 November 2020, from https://www.unisdr.org/files/7817_UNISDRTerminologyEnglish.pdf

United Nations [UN]. (2020). UN report: Dramatic rise in climate disasters over last 20 years. *United Nations Philippines.* Retrieved 20 November 2020, from https://philippines.un.org/en/95345-un-report-dramatic-rise-climate-disasters-over-last-20-years.

Valk, J., Rashid, A., & Elder, L. (2010). Using mobile phones to improve educational outcomes: An analysis of evidence from Asia. *The International Review Of Research In Open And Distributed Learning*, 11(1), p.117. Retrieved 17 November 2020 from https://doi.org/10.19173/irrodl.v11i1.794

Villarin, J. R. T., Algo, J. L. C., Cinco, T. A., Cruz, F. A. T., de Guzman, R. G., Hilario, F. D., Narisma, G. T. T., Ortiz, A. M. D., Siringan, F. P., & Tibig, L. V. (2016). 2016 Philippine Climate Change Assessment. 36th Flr. One Corporate Center Bldg. Julia Vargas corner, Meralco Avenue, Ortigas Pasig City 1605 Philippines; The Oscar M. Lopez Center for Climate Change Adaptation and Disaster Risk Management Foundation Inc.

Wahyudin, D., & Hasegawa, S. (2017). The Role of Serious Games in Disaster and Safety Education: An Integrative Review. *Workshop Proceedings Of The 25Th International Conference On Computers In Education. New Zealand: Asia-Pacific Society For Computers In Education*. Retrieved 2 December 2020 from https://www.apsce.net/icce/icce2017/140.115.135.84/icce/icce2017/sites/default/files/proceedings/workshops/W4/The%20Role%20of%20Serious%20Games%20in%20Disaster%20and%20Safety%20Education%20An%20Integra.pdf

World Bank. (2014). *Forum on Safe and Resilient Infrastructure Proceedings Report*. Manila, Philippines. Retrieved from https://www.gfdrr.org/sites/gfdrr/files/Philippines-Forum-on-Safe-and-Resilient-Infrastructure.pdf

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