Asian Journal of Science Education
Vol. 6. No. 1, April (2024) 155 – 168

e-ISSN 2715-5641
DOI: doi.org/10.24815/ajse.v6i1.35768

Asian Journal of Science Education

Journal homepage: https://jurnal.usk.ac.id/AJSE

HYDRA: A Board Game for Disaster Risk Knowledge, Awareness and Preparedness on Hydrometeorological Hazards

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ARTICLE HISTORY.

Submited	: 02 December 2023
Reviewed	: 14 December 2023
Accepted	: 04 May 2024
Publication	: 04 May 2024
Avaible *Online*	: 04 May 2024

KEYS WORDS.
Instructional material, board game, hydrometeorological hazards, disaster readiness and risk reduction

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ABSTRACT.
The inclusion of DRR education in the curriculum has been part of the response of the government to the increasing threats of disasters in the Philippines. Yet it was found out that students are still mostly uncertain when a disaster occurs, more specifically on evacuation plans, hazards and disaster-prone areas . This study aimed to develop an instructional material to increase the knowledge, preparedness, and awareness towards hydrometeorological hazards of Grade 11 students in Caloocan City Science High School. The Hydrometeorological Disaster Risk Awareness board game (HYDRA), was first evaluated by seven DRRR experts and Science teachers using the DepEd LRMDS evaluation tool, before it was implemented to the Grade 11 students. Data were collected from 20 participants using a 20-item test questionnaire and a 16-item survey form. The results of the pretests and posttests have shown significant differences with large effect sizes, which implies that the game has significantly increased the students' disaster risk knowledge ($p < 0.001$; $d = 1.5$), preparedness ($p < 0.001$; $d = 1.92$), and awareness ($p < 0.001$; $d = 1.96$). The game also received an overall evaluation rating of 3.99 out of 4, which means that it met the criteria for an appropriate instructional material. These findings suggest that HYDRA can be used as an alternative educational tool in teaching DRRR.

INTRODUCTION

The Philippines is one of the countries that are highly susceptible to disasters caused by natural hazards and is ranked third out of 173 countries with high levels of disaster risk, according to the World Risk Report in 2018. One reason for this is its geological location belonging to the Pacific Ring of Fire and in the path of tropical cyclones (Mamon, 2017). According to the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA), an average of 20 tropical cyclones enter the Philippine Area of Responsibility (PAR) annually. Looking back on the yea, the country has recorded its largest economic loss that was associated with Typhoon Yolanda, which is considered one of the strongest typhoons to make landfall in history. Most damages were caused by the hydrometeorological hazards caused by the typhoon, such as storm surges, strong winds, and prolonged rainfall. In addition, results from the study of Cinco et al. (2016) have shown an increasing trend of the normalized cost of damages brought by tropical cyclones, which implies their major socioeconomic impacts on the country.

In response to the increasing threats of disasters in the country, the government implemented the Philippine Disaster Risk Reduction and Management Act of 2010, also known as the Republic Act of 10121. The law includes a proactive strategy for addressing disaster risks and is the guiding policy framework to strengthen disaster risk governance across different governance levels (UNDRR, 2019). The DRRM Act also mandates including disaster risk reduction (DRR) Education in primary and secondary school curricula. In compliance with this act, DRR education was added in the K-12 basic education curriculum in Earth and Life Science, as well as in Disaster Readiness and Risk Reduction (DRRR). Comprehensive and improved knowledge of disaster education is promoted among students as part of the K–12 program as it is crucial to safety practices and resiliency to disaster risk (Moradian & Nazdik, 2019). It aims to promote resiliency among students by strengthening their knowledge, awareness, and understanding of the different hazards and developing their skills in preparing and responding to the damaging effects of disaster (Mamon, 2017; Tuladhar et al., 2015).

Despite the implementation of DRR Education, a low perception of disaster risks has been observed among students (Mamon, 2017). In a study conducted by Toyado (2022), it was found out that students are mostly uncertain when a disaster occurs and have no proper understanding of calamities. As for disaster preparedness, most of them are uncertain about the evacuation plans, routes, evacuation centers, and open space in case of a disaster, as well as the hazards and disaster-prone areas. Toyado (2022) stated that this is a serious matter that needs to be solved so that students would be able to take the right actions towards the imminent dangers of natural hazards.

`In a meta-research done by Selby and Kagawa (2012), they examined the key national experiences in integrating disaster risk reduction (DRR) in the education curriculum of 30 countries. It was found that the most common approach in integrating DRR is by infusing disaster-related topics into different subjects. Despite this, it was stated that most of the learning and teaching approaches for DRR curriculum tend to be generally limited in application. Only a few successful interactive and experiential learning approaches were found across different case studies. There is only a few evidence for affective learning approaches involving the learners' feelings and learning experiences and how they affect the learners' attitude and behavior (Selby & Kagawa, 2012).

According to a status report 2019, one of the key gaps regarding disaster risk reduction in the Philippines is the limited amount of attention and resources devoted to DRR research. Though new applications and websites about geological and hydrometeorological hazards were launched, it is recognized that there are differences and limitations in the utilization of technology in different schools (Reyes, 2019). Thus, alternative solutions, including the physical production of learning materials, could be more effective in providing information to the learners.

Per the designed conceptual framework shown in Figure 1, this study aims to develop a validated Board Game and determine its efficiency in increasing the disaster-related knowledge, awareness, and preparedness of Grade 11 students in Caloocan City Science High School. This study also aims to answer the following specific research questions:

1. Was the game able to achieve the target criteria to be considered valid instructional material from the evaluation of experts?
2. Is there a significant difference between the pretest and posttest scores of the Grade 11 students before and after the intervention of the HYDRA board game?
3. Is there a significant difference between the disaster risk awareness and preparedness of the Grade 11 students before and after the intervention of the HYDRA board game?

Using instructional materials improves students' achievement and enhances students' cognitive, psychomotor and affective domains (Erediano et al., 2021; Zuniari et al., 2023). Therefore, this study focused on using a physical game as a DRR instructional material. Game-based learning provides an opportunity for the development of skills and knowledge of students and encourages them to understand the concepts to achieve their goals (Abdul Jabbar & Felicia, 2015; Lin et al., 2021; Viray, 2016). Additionally, an experimental study conducted by Huizenga et al. (2009) assessed a mobile game's understanding and motivational effects on students' learning of historical knowledge of Medieval Amsterdam. It was found that the students who played the game showed engagement and gained significantly more knowledge than those who experienced a regular, project-based learning mode.

Since there is no dedicated DRR subject in JHS and other SHS strands, the game will be able to help students with limited knowledge in the mentioned scope of the game, specifically, Grade 11 students. The results of this study will be of help not only to the students but also to the whole educational sector. Once proven effective in obtaining its objectives, the game may be used by faculty members and the academic staff as a material to impart information to students about the definition of terms related to disaster risk as well as the hydrometeorological hazards prevalent in our country while boosting the interest and engagement of the students. This research will also contribute to the existing limited evaluations of the effects of game-based learning.

The exploration of the study only focuses on Grade 11 students as the target participants and thus would not be able to generalize the results to the other grade levels. The game will only include the hydrometeorological hazards stated in the Essential Learning Competencies (MELCs) provided by the Department of Education and the basic concepts and terminologies in DRRR.

RESEARCH METHODS

Research Approach

This study is being conducted as a research and development type of research wherein the ADDIE development model is utilized. It is one of the frameworks for systematic learning design that was chosen after considering that it was developed methodically and is based on the theory of learning design. To address issues with learning materials that align with students' requirements and characteristics, this model is structured and programmed with sequences of systematic activities. There are five phases in this model: (1) analysis, (2) design, (3) development, (4) implementation, and (5) evaluation (Mustika et al., 2023). Figure 2 shows the ADDIE Model phases graphically.

a. Analysis

Severe hazard occurrences, such as La Niña and El Niño, tropical cyclones, and storm surges, frequently occur in the Philippines. These calamities have been worse and more frequent over the previous ten years, which harms the exposed population, especially its poorest portion (Ravago, 2018). Therefore, the game emphasizes the effects of these frequently occurring hydrometeorological disasters in our country. The specific competencies that were identified from The DepEd Most Essential Learning Competencies (MELC) and focused on in the game include the following:

1. Define and cite examples of the types of hazards
2. Differentiate among hazards, exposure, and vulnerabilities and explain the relationship of the three to disaster risk
3. Apply mitigation strategies to prevent loss of lives and properties
4. Prepare survival kits and materials for one's family and for public information and advocacy

The intended goal is for the learners to be educated regarding these specific learning competencies in DRRR, while having fun simultaneously in the board game setting.

b. Design and Development

HYDRA, or Hydrometeorological Disaster Risk Awareness board game, is a game in which players move around a board intending to survive the hazardous areas they will encounter. Throughout the game, the players will acquire different items and action cards that will help them increase their capacity, thus decreasing their disaster risk. The game's main goal is to be the most disaster-ready citizen out of the group with the lowest level of disaster risk. HYDRA familiarizes the players with the most common hazards that come with our country's four main hydrometeorological hazards, allowing them to appreciate the importance of the necessary items in a survival kit when faced with a disaster.

- Setting Up

  The game starts with 3-5 players seated in a circle with the board placed in the middle. One of them must first draw one small envelope out of the four and this will serve as the group's game mode all throughout the game. The four game modes presented in Figure 3 are the main hydrometeorological hazards: La Niña and El Niño, tropical cyclones, and storm surge. Each mode will provide fixed hazard points equally to every player.

Figure 1. Four hazard game mode envelopes and their corresponding hazard points cards are to be distributed to each player

Next, every player must roll the character dice to pick their character. The six characters consist of the six vulnerable groups which are the children, elderly, pregnant, prisoners, economically disadvantaged, and disabled. More than one player may choose a character, and each character will have a corresponding number of fixed vulnerability points given to the players. The player's character will also indicate the chip they will use during the game.

Figure 2. Residence cards

Lastly, the players will choose their residence by simultaneously picking a residence card (Figure 2) that must be faced down before revealing their residence once everyone has picked. The player's residence determines their fixed exposure points throughout the game and must be placed down beside the hazard mode cards. There are five residences that may be picked namely Metro Manila, Sorsogon, Cagayan de Oro, Mandaluyong City and Bicol Region. These places in the country are highly exposed to hydrometeorological hazards due to their location or population density. These cards aim to inform the students about how the location and population density affects one's exposure to hazards.

These fixed hazard, vulnerability, and exposure points determined by the hazard mode, character, and residence, respectively, may not be refuted by the players and will be fixed until the end once the disaster risk will already be computed. Before the game starts, each player must be given two cards from the main deck which they could use for later. Then the sequence of the players' turns will be decided by rolling the dice, starting from the highest rolled number to the lowest.

- How to Play

The game starts with every player's chip at the starting point of the board. The first player must always draw two cards from the main deck before rolling a dice or putting down an action card. They will move their chip according to the number of spaces the dice indicates. Depending on the area the chip lands on, the player may use a card to defend themselves from the hazard points given by the location on the board. If not, they will be given hazard skull cards by the facilitator. If they could refute using an item card with a higher number, the difference would be given to them in the form of heart cards. Additionally, each card would include short information or trivia about DRRM. If the player's chip lands on a box containing a mission, the facilitator must ask a question from the question sheet, which the player must answer correctly to gain capacity points.

Points are categorized as capacity, hazard, exposure, and vulnerability points. Each card has a corresponding number of points indicated in its corners. Hazard points may be gotten from the board, vulnerability points from event cards, and exposure points from one single exposure card that may be drawn from the deck. The players have to match or surpass the number of hazard or vulnerability points that they will encounter in each turn with an appropriate card that also has a corresponding capacity point. The exposure card, however, can't be refuted once drawn and must be kept a secret until the end of the game. This may be passed onto another player once they use a steal action card.

The game would end after one complete revolution around the board. Once every player has reached the end, the disaster risk points will be computed, including the fixed points every player received at the start, and the winner will be acknowledged. Players must gain as many capacity points and as few hazard, vulnerability, and exposure points as possible. The player with the least disaster risk wins at the game's end.

- Pointing System

A pointing system is used to decide the results at the end of the game. All the same types of points will be added first before the hazard, vulnerability, and exposure points are multiplied.

- Components

Board

Figure 3. HYDRA board

The board (Figure 3) is where the chips representing each player's character move. It is divided into secondary hazards under the four main hydrometeorological hazards the players would encounter in the game. The board provides short information regarding these hazards that will enhance their knowledge about them.

Figure 4. Item card, action card, and event card

10 Event Cards

The event card (Figure 6) consists of essential situations that would increase one's vulnerability during a disaster. An item card may also defend these cards during their turn. It is up to the player whether they will keep them or refute them by item cards.

20 Item Cards

This type of card (Figure 6) contains items that may be used once faced with a hazard to avoid gaining hazard points. Each item has its corresponding capacity points. This would familiarize the players with the essential items that must be present in a survival kit.

20 Action Cards

This card (Figure 6) shows preventive measures that may be used during their turn. Most of these cards involve other players. In this way, player interaction and engagement would be maintained all throughout. What these cards do are indicated on the card. At every turn, a maximum of only 2 action cards are allowed to be used. At the end of the game, each unused action card corresponds to one (1) capacity point.

Question Sheet

This contains questions to test the player's disaster-related knowledge and will be used once the player's chip lands on a box containing a question mark. The facilitator will first ask the type of question they would like to answer. True or false questions give one capacity point, multiple choices give two, while identification questions give three. The player will roll the dice to determine the number they will answer under their chosen difficulty. The player must correctly answer it to gain capacity points. Once they fail, the corresponding vulnerability points will be given.

Research Participants

Phase 1

The board game was evaluated to ensure the effectiveness and validity by three evaluators from the Schools Division Office of Caloocan City with expertise in DRRM and education, and four science teachers using the LRMDS Guidelines provided by DepEd, more specifically, the Evaluation Rating Sheet for Charts, Posters, Drill/Flash Cards and Manipulatives. The form includes a section asking for their feedback and insights for improvement. To assess the evaluators' ratings appropriately, Table 1 shows the basis of the interpretation of the ratings on a 4-point Likert scale, which was adapted from a paper conducted by Pimentel (2019).

Phase 2

The target participants for this study are Grade 11 students at Caloocan City Science High School. They were chosen as there is no dedicated DRR subject in JHS and other SHS strands, which increases the vulnerability of the students in terms of disaster-related knowledge. After getting permission from the school's Officer-in-Charge to conduct the pilot testing involving the target student participants, two sections from the batch of Grade 11 students were randomly chosen during the 4th quarter of the school year 2022-2023. Among the selected sections, 20 participants were identified through convenience sampling, with 10 students in each section.

Research Instruments

Two instruments were used during the pilot testing to determine the effects of the game on the students' disaster-related knowledge, awareness, and preparedness. The 20-item multiple choice test questionnaire constructed by the researchers aims to determine the difference between the disaster-related knowledge of the students before and after playing HYDRA. Moreover, the survey questionnaire sheet, which the researchers also made aims to determine the difference between the disaster awareness and preparedness of the students before and after intervention. Under the awareness and preparedness categories were statements in which the students' level of agreement were asked in the form of a five-point Likert scale. To have an appropriate discussion of the data obtained on the survey form, Table 2 was used as a basis, which was also used in a study conducted by Nyutu et al. (2021).

Both instruments went under face and content validity and internal consistency to measure reliability. They were first validated by a DRRR teacher and a science teacher to identify the items that required revisions. Once the necessary revisions were done, the researchers received the teachers' approval. The test questionnaire and survey form were administered to the same group of students during two different periods. Cronbach's alpha is a measure of reliability that is interpreted in terms of internal consistency and, therefore was used on both instruments. The computed alpha values for both the test questionnaire (α=0.538) and survey forms on disaster preparedness (α=0.659) and disaster awareness (α=0.730) fall under the range of 0.5-0.8. Based on the common interpretation of Cronbach's alpha, $0.5 < \alpha < 0.8$ is considered moderate (acceptable) reliability (Ekolu & Quainoo, 2019).

Data Collection

Data collection was carried out through questionnaires and Google forms, which can be accessed online. Interested students were asked to complete a Google Form to provide their name, grade, and section. Each participant was also given a parental permission form and an informed consent form, which they were required to sign to ensure their complete willingness and permission to participate in the study.

On the day of the data collection, the students were first given 15 minutes to answer a 20-item test questionnaire and a 16-item survey questionnaire provided by the researchers that contained questions and statements regarding the DRRM concepts that would be discussed and familiarized during the game. Afterward, the students were oriented with the rules and mechanics before finally starting the game. The next day, the same test questionnaire and survey form were provided to the same group of students, and 15 minutes was also needed to complete them.

Data Analysis

The Jamovi statistical software was used to analyze the raw data gathered. The normality test was first run to decide if a parametric or non-parametric test would be used. The Shapiro-Wilk test was used since it is the appropriate normality test for small sample sizes (n<50). Descriptive statistics such as means and standard deviations were used throughout the analysis. Since the data consists of the pretest and posttest scores of the same group of participants, a Paired sample t-test was used to determine if they are significantly different.

RESULTS AND DISCUSSION

Results

Evaluation of Science and DRRR teachers

Table 3. Descriptive analysis of HYDRA evaluation scores

	Mean	SD	Interpretation
Content	3.96	0.0964	Very Satisfactory
Other Findings	4.00	0.0000	Very Satisfactory
Instructional and Technical Design	4.00	0.0000	Very Satisfactory
OVERALL AVERAGE	3.99	0.0231	Very Satisfactory

Pilot Testing on Grade 11 Students

Table 4. Test for normality of students' pretest and posttest scores

	W	p
Pretest - Posttest	0.953	0.416

In order to decide the appropriate statistical method to be used, the Shapiro -Wilk Normality test was used to determine the distribution of the data gathered since it is the appropriate method for small sample sizes ($n<50$). Since $P > 0.05$ was shown in Table 4 for the Shapiro-Wilk Normality test ($W=0.953$, $p=0.416$), the null hypothesis is accepted and data are called as normally distributed. Thus, a parametric test can be implemented to analyze the difference between the two sets further.

Students' Disaster-Related Knowledge before and after Intervention

Table 5. Students' pretest and posttest scores

Participant	Pretest	Post Test
1	10	14
2	13	16
3	7	10
4	10	17
5	9	12
6	11	18
7	9	13
8	8	18
9	14	17
10	13	17
11	7	11
12	12	14
13	15	16
14	12	11
15	12	14
16	10	17

Participant	Pretest	Post Test
17	10	18
18	8	14
19	14	15
20	12	15

As presented in Table 5, there is an increase in the lowest and highest scores on the pretest and posttest, with seven as the lowest 15 as the highest in the pretest, ten as the lowest, and 18 as the highest in the posttest. It was also observed that 19 out of 20 students had an increase in their scores in the posttest after the intervention of the game.

Table 6. Descriptive analysis of student's level of disaster-related knowledge on hydrometeorological hazards

	Sample Size	Mean	SD
Pretest	20	10.80	2.38
Posttest	20	14.85	2.50

Table 6 compares the means and standard deviations of the pretest and posttest scores. With the pretest having a mean of 10.8 (SD=2.38) and the posttest having a mean of 14.85 (SD=2.50), this suggests an improvement in the students' disaster-related knowledge after playing HYDRA.

Table 7. Paired sample t-test for the effectiveness of hydra on students' level of disaster-related knowledge

	statistic	df	p	Mean Difference	Cohen's d Effect Size
Pretest - Posttest	- 6.70	19.0	< .001	4.05	1.50

The pretest and posttest scores of the participants were compared using the paired sample t-test to determine if there was a significant difference between them.

Table 8. Normality Test (Shapiro-Wilk) for pre-survey and post-survey score on disaster preparedness and awareness

	W	p
Pretest Disaster Preparedness - Posttest Disaster Preparedness	0.981	0.950
Pretest Disaster Awareness - Posttest Disaster Awareness	0.967	0.687

To determine the appropriate statistical tests to analyze further the data gathered from the Disaster Preparedness and Awareness survey form, the Shapiro-Wilk Test (n<50) was used to check for the normality of the scores in both pre-survey and post-survey. The results shown in Table 8 indicate that p-value<0.05 for the posttest scores on disaster preparedness (0.950) and disaster awareness (0.687). This implies that the assumption of normality was not violated, and therefore, a parametric test must be used to assess if there is a significant difference between the scores before and after the intervention.

Students' Disaster Awareness and Preparedness before and after Intervention

Table 9. Pretest-posttest responses of students on disaster preparedness

	Pretest			Posttest		
	Mean	SD	Interpretation	Mean	SD	Interpretation
Disaster Preparedness						
1. I know what to do before, during, and after a disaster.	3.85	0.875	Agree	4.85	0.366	Strongly Agree

	Pretest			Posttest		
	Mean	SD	Interpretation	Mean	SD	Interpretation
2. I know that having an evacuation plan is important.	4.95	0.224	Strongly Agree	5	0	Strongly Agree
3. I know that having a disaster kit is important.	4.85	0.489	Strongly Agree	5	0	Strongly Agree
4. I know the important items needed to be included in a disaster kit.	3.85	0.745	Agree	4.8	0.410	Strongly Agree
5. I know where I should go after a disaster.	3.75	0.851	Agree	4.6	0.598	Strongly Agree
6. I am aware of the necessary steps that could help me when faced with a hydrometeorological hazard.	3.4	0.995	Neutral	4.75	0.444	Strongly Agree
7. I know that structures made of light materials can be vulnerable to disasters.	4.4	0.995	Strongly Agree	4.85	0.366	Strongly Agree
8. I know the importance of having a list of emergency hotlines in case of disaster.	4.6	0.821	Strongly Agree	5	0	Strongly Agree
OVERALL AVERAGE	**4.21**	**0.570**	**Strongly Agree**	**4.86**	**0.143**	**Strongly Agree**

Table 9 compares the pretest and posttest means in terms of the Disaster Preparedness of the students. As seen in Table 9, all Neutral and Agree interpretations from the pretest changed into Strongly Agree interpretations. All statements showed an increase of mean after the intervention. The statements with the highest mean increase were statements 1, 4, and 6. This indicates that although HYDRA was able to improve the students' preparedness in terms of every statement, the game was most effective in preparing the students about the things to do before, during, and after a disaster, the necessary items in a disaster kit, and the steps that could help them when faced with a hydrometeorological hazard.

Table 10. Pretest-posttest responses of students on disaster awareness

	Pretest			Posttest		
	Mean	SD	Interpretation	Mean	SD	Interpretation
Disaster Awareness						
1. I am aware that a hydrometeorological disaster can happen at any time.	4.6	0.821	Strongly Agree	4.9	0.308	Strongly Agree
2. I am aware of the different hydrometeorological hazards that affect the country.	3.85	1.089	Agree	4.9	0.308	Strongly Agree
3. I am aware of the matters that increase the vulnerability of my community.	3.8	0.834	Agree	4.8	0.410	Strongly Agree

	Pretest			Posttest		
	Mean	**SD**	**Interpretation**	**Mean**	**SD**	**Interpretation**
4. I know that proper environmental management is important in reducing impacts of disasters.	4.7	0.571	Strongly Agree	4.9	0.308	Strongly Agree
5. I am familiar with the hazard-prone areas in the country.	3.35	0.875	Neutral	4.75	0.550	Strongly Agree
6. I am aware that factors like being near a coastal area or being in a low elevation area increase the exposure of a community to hydrometeorological hazards.	4.6	0.598	Strongly Agree	4.95	0.224	Strongly Agree
7. I am familiar with the secondary hazards that come with tropical cyclones, storm surge, El Niño and La Niña.	3.55	0.826	Agree	4.8	0.523	Strongly Agree
8. I am aware that the ability to cope when faced with a hydrometeorological hazard is crucial.	4.55	0.510	Strongly Agree	4.9	0.308	Strongly Agree
OVERALL AVERAGE	4.125	0.544	Agree	4.86	0.0694	Strongly Agree

Table 10 compares the pretest and posttest means in terms of the Disaster awareness of the students. Just like in the data gathered under Disaster Preparedness, all statements above showed an increase in mean after the intervention, and the Neutral and Agree interpretations in the pretest changed into Strongly Agree interpretations in the posttest. Statements 2, 3, 5, and 7 had the highest increase of means, which implies that under Disaster Awareness, HYDRA was most effective in increasing the students’ awareness towards the matters that increase one’s vulnerability to disasters, the hazard-prone areas in the country, and the hydrometeorological hazards affecting the country as well as the secondary hazards that come with them.

Table 11. Paired sample t-test on the effectiveness of hydra on students’ level of disaster preparedness

	statistic	**df**	**p**	**Mean Difference**	**Cohen’s d Effect Size**
Pretest Disaster Preparedness - Posttest Disaster Preparedness	- 8.59	19.0	< .001	5.20	1.92

Table 12. Paired Sample t-Test on the effectiveness of HYDRA on students’ level of disaster awareness

	statistic	**df**	**p**	**Mean Difference**	**Cohen’s d Effect Size**
Pretest Disaster Awareness- Posttest Disaster Awareness	- 8.77	19.0	< .001	5.90	1.96

Discussion

Following the data collected in Table 3, researchers obtain the mean and standard deviation of the ratings of the seven evaluators on each aspect of the game under the LRMDS Guidelines Evaluation Sheet were determined. Out of a perfect score of 4.00, the game received a mean score of 3.96 for content, which indicates that the game is accurate and appropriate in terms of its content and visuals. The game also received a perfect mean score 4.00 for both Instructional and Technical Design and Other Findings. This implies that the material is safe to use, the size and composition of the game are appropriate for its target users, and no conceptual, factual, grammatical, and other errors were found. As all evaluated factors acquired a Very Satisfactory interpretation, this indicates that HYDRA successfully met the standards of the DRRR experts and Science teachers. Additionally, all evaluators recommended the approval of HYDRA for possible use in schools.

The total points each evaluator gave for each criterion were also computed (refer to Appendix B). The game received scores of 39 and 40 for the content, and reached the required total points of at least 30 to pass the criterion as per the DepEd LRMDS Guidelines. Regarding the Other Findings and the Instructional and Technical Design, perfect scores of 16 and 24 were obtained, respectively, also passing these criteria. These findings allowed the researchers to proceed to the trial phase of the study with the results seen in Table 4.

The paired sample t-test was also used on the survey scores before and after the intervention of HYDRA. Data sets under Disaster Preparedness showed $p<0.001$, meaning there is a significant difference between the pre-survey and post-survey scores, this implies that the researchers were able to gather more positive responses in the post-survey compared to the pre-survey, indicating that HYDRA was able to increase the students' level of disaster preparedness. An effect size of 1.92 also indicates a large effect according to Cohen's d effect size interpretation (Téllez et al., 2015), which implies that the difference between the pre-survey and post-survey scores was large enough and is considered meaningful, this is similar to the findings presented in another game-based learning study by Ersani (2021), which also used a physical game to improve the disaster preparedness of grade 11 students. Their results proved that their game is truly successful in increasing the students' disaster preparedness and is, therefore, another study shows the effectiveness of using a physical game as an alternative instructional material.

Table 12 shows the results of the paired sample t-test for the Disaster Awareness aspect. A result of $p<0.001$ means that there is a significant difference between the pre-survey and post-survey scores of the students. These results indicate that HYDRA improved the students' level of disaster awareness towards hydrometeorological hazards. Additionally, a large effect size (Téllez et al., 2015) of 1.96 indicates that the results were meaningful and practically significant. In line with this, findings from the study done by Adamantopoulos et al. (2014) also revealed that implementing concepts of gamification could further increase the motivation and interest of people in learning disaster mitigation and preparedness concepts and applying them in real life. According to Solinska-Nowak et al. (2018), some serious games require the players to acquire experience in crises or put the players in roles to cope with difficult circumstances. This leads to a higher understanding of the scenarios they might use.

CONCLUSION

The evaluations of HYDRA given by the seven expert evaluators show that the board game's usability and technicality met the required criteria regarding its content, lack of errors, and instructional and technical design. These findings support the appropriateness of the board game as an instructional material that can help in the achievement of the specified DRRR content standards covered by the game, which includes the basic concepts of disaster, disaster risk, disaster risk reduction and management for preparedness, and the most prevalent hydrometeorological hazards in the country.

The results of the pretest and posttest of the Grade 11 participants showed a significant difference, which implies that the board game was able to improve the students' disaster-related knowledge in terms of the concepts included in the game. Moreover, the results from comparing the post-survey and pre-survey ratings in terms of Disaster Preparedness and Awareness indicate that HYDRA significantly increased the students' level of disaster awareness and preparedness towards hydrometeorological hazards. Pretest and posttest scores under the knowledge, awareness, and preparedness aspects showed a large effect size, which indicates that HYDRA was not only statistically significant but also practically significant, which means that the effect of the game is large enough to be meaningful.

Overall, the results suggest that HYDRA can increase students' disaster risk knowledge, awareness, and preparedness toward hydrometeorological hazards and, therefore can be used as an alternative educational tool in teaching DRRR. Since HYDRA is an instructional material that only focuses on basic concepts of disaster, disaster risk, and disaster risk reduction and management for preparedness, exploring other topics under the DRRR learning competencies is recommended. The researchers also recommend adding more examples of places in the Philippines that are highly exposed to hydrometeorological hazards since this study could only focus on five. Furthermore, it is also suggested that the target participants be expanded by conducting pilot testing on other grade levels. Game development researchers may also conduct more than one game playthrough session to enhance the experience and further develop the knowledge and skills desired to be measured.

Acknowledgment
The researchers would like to thank the Caloocan City Science High School faculty and the Schools Division Office - Caloocan City for validating and evaluating the game and its content, and for giving their insightful comments and suggestions for the best outcome of this research. The researchers would also like to gratefully acknowledge their family, especially Mrs. Emelinda B. Arcilla and Mr. Julandy B. Arcilla for their dedicated help in the physical reproduction of our board game. This study was made possible by the CCSHS Science Research Committee and Dr. Jocelyn M. Aliñab for the approval of the research.

References

Abdul Jabbar, A. I., & Felicia, P. (2015). Gameplay engagement and learning in game-based learning: A systematic review. *Review of educational research*, *85*(4), 740-779.

Adamantopoulos, G. M., Fullero, M., Sembrano, F. M., & Nuel, A. (2014). Exploring Gamification and Related Models In Enhancing Disaster Mitigation and Preparedness. *In DLSU Research Congress*, 1-6.

Cinco, T. A., de Guzman, R. G., Ortiz, A. M. D., Delfino, R. J. P., Lasco, R. D., Hilario, F. D., ... & Ares, E. D. (2016). Observed trends and impacts of tropical cyclones in the Philippines. *International Journal of Climatology*, 36(14), 4638-4650.

Ekolu, S. O., & Quainoo, H. (2019). Reliability of assessments in engineering education using Cronbach's alpha, KR and split-half methods. *Global journal of engineering education, 21*(1), 24-29.

Erediano, W. M., Luna, S. E., Buan, A. T., Gomez, R. G., & Malicoban, E. V. (2021). Improvised early flood warning device as a learning material in teaching student's preparedness for disaster risk management. *In Journal of Physics: Conference Series*, 1835(1), 012036. IOP Publishing.

Ersani, E. (2021). Disaster Mitigation Snake and Ladder Game to Improve Earthquake Disaster Preparedness (A Case Study: Yogyakarta 5 Senior High School). In *IOP Conference Series: Earth and Environmental Science*, 884(1), 012042. IOP Publishing.

Huizenga, J., Admiraal, W., Akkerman, S., & Dam, G. T. (2009). Mobile game-based learning in secondary education: engagement, motivation and learning in a mobile city game. *Journal of Computer Assisted Learning*, 25(4), 332-344.

Lin, H. C. K., Lin, Y. H., Wang, T. H., Su, L. K., & Huang, Y. M. (2021). Effects of incorporating augmented reality into a board game for high school students' learning motivation and acceptance in health education. *Sustainability, 13*(6), 3333.. https://doi.org/10.3390/su13063333

Mamon, M. A. C., Suba, R. A. V., & Son, I. L. (2017). Disaster risk reduction knowledge of Grade 11 students: Impact of senior high school disaster education in the Philippines. *International Journal of Health System and Disaster Management*, *5*(3), 69.

Moradian, M., & Nazdik, Z. M. (2019). Game versus Lecture-Based Learning in Disaster Risk Education; An Experience on Shiraz High School Students. *Bulletin of Emergency and Trauma*, *7*(2), 112–117. https://doi.org/10.29252/beat-070204

Mustika, C. R., Aida, N., & Sihaf, A. N. (2023). Development of Learning Modules Based Numbered Head Together (NHT) on Substance Pressure Material at the Junior High School Level. *Asian Journal of Science Education*, *5*(2), 48-56.

Nyutu, E., Cobern, W. W., & Pleasants, B. A. (2021). Correlational study of student perceptions of their undergraduate laboratory environment with respect to gender and major. *International Journal of Education in Mathematics, Science and Technology, 9*(1), 83-102.

Pimentel, J. L., & Pimentel, J. L. (2019). Some biases in Likert scaling usage and its correction. *International Journal of Science: Basic and Applied Research (IJSBAR), 45*(1), 183-191.

Reyes, M. R. B. (2019). Implementing DRR Education in Senior High School . Retrieved from https://www.academia.edu/download/88043143/Reyes_2019_Implementing_DRR_Education_in_SHS.pdf

Selby , D., & Kagawa , F. (2012). Disaster Risk Reduction in School Curricula: Case Studies from Thirty Countries. Retrieved from https://www.preventionweb.net/files/26470_drrincurriculamapping30countriesfin.pdf

Solinska-Nowak, A., Magnuszewski, P., Curl, M., French, A. J., Keating, A., Mochizuki, J., Liu, W., Mechler, R., Kulakowska, M., & Jarzabek, L. (2018). An overview of serious games for disaster risk management – Prospects and limitations for informing actions to arrest increasing risk. *International Journal of Disaster Risk Reduction*, *31*, 1013–1029. https://doi.org/10.1016/j.ijdrr.2018.09.001

Tellez, A., Cadena, C. H. G., & Corral-Verdugo, V. (2015). Effect size, confidence intervals and statistical power in psychological research. *Psychology in Russia: State of the Art*, 8, 27-46. https://doi.org/10.11621/pir.2015.0303.

Tuladhar, G., Yatabe, R., Dahal, R., & Bhandary, N. P. (2015). Disaster risk reduction knowledge of local people in Nepal. *Geoenvironmental Disasters*, 2, 1-12. https://doi.org/10.1186/s40677-014-0011-4.

UNDRR. (2019). Disaster Risk Reduction in the Philippines: Status Report 2019. Bangkok, Thailand, United Nations Office for Disaster Risk Reduction (UNDRR), Regional Office for Asia and the Pacific.

Viray, J. (2016). Engaging students through board games: Measuring its effectiveness on academic performance. *International Journal of Scientific and Research Publications, 6*(10), 5-7.

Zuniari, N. I., Wahyuni, S. W., & Ridlo, Z. R. (2023). The Development of Science Teaching Materials Based on Android Mobile to Improve Critical Thinking Skills in Junior High School Students. *Asian Journal of Science Education, 5*(1), 54-69.