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Developing "Guess-Huwhat?" Strategic Intervention Material to Engage Grade 12 STEM Students in Understanding the Sound Terminologies

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ABSTRACT

Teaching of sound concepts must be improved and presented in new ways to lessen misconceptions. One of the efficient teaching methods for sciences is the use of strategic intervention material (SIM) because it assists students in enhancing their learning towards the least-learned subjects or competencies. This research aimed to develop a strategic intervention material, Guess HuWhat?, in teaching the concepts of sounds to STEM senior high school students. It also aimed to lessen the misconceptions about the concepts of sounds and improve the students' conceptual understanding of sounds. The study adapted Branch's ADDIE model, which stands for Assess, Design, Develop, Implement, and Evaluate, as the basis for developing the actuarial mathematics course materials. This developed strategic intervention material was evaluated by Science Content Experts and was further utilized by some of the Grade 12 STEM students at Muntinlupa National High School to find out its effectiveness as a learning supplementary material and based on the data gathered, the Guess HuWhat? Strategic Intervention Material improved grade 12 STEM students' understanding of sound terminologies. By repetitive actions, the developed game-based SIM can be an effective intervention material to deepen students' comprehension of sound concepts and strengthen camaraderie among learners. This study recommends Guess HuWhat? Game in grade 12 science classes for continuous enhancement of teachers' craft as well as innovation of the game itself. Moreover, it is highly recommended that teachers design and develop other game-based activities containing concepts that they perceive students are struggling with promoting that learning is indeed fun.

INTRODUCTION

Sound was introduced in the science curriculum in the Philippines in the 3rd Quarter of Grade 7 Junior High School (Department of Education, 2016). Numerous studies have reported that students have difficulty understanding sound concepts. The study of Periago, et.al., (2009) revealed that although students can describe how sound travels in the air, they find it difficult to explain how sound travels through a solid wall. Similar observations were noticed such as Physics students often encounter difficulties explaining their knowledge of some concepts in their undergraduate physics program and it has been revealed that students' comprehension of sound concepts is low and a significant percentage of students who do express alternative ideas (Linder, 1989; Aygün, *et al.* (2022). In the study of Wallin, *et al.*, (2012), students have a tough time comprehending abstract concepts like sound, especially when it comes to understanding and using a general model of sound transmission. According to Arcadi, et.al., (2011), the application of the sound model to sound qualities by students was frequently inconsistent and not fully understood by the learners despite the perceptions of claiming that they have learned the concepts.

Teachers also experience difficulties when it comes to understanding concepts of sound. According to the findings of the study of Ozturk. *et al.* (2012), among the 60 students enrolled in classroom teaching education and 40 students enrolled in the Science Education program, prospective teachers had misconceptions about sound. In the study of Aygun *et. al*, (2022), the conceptual shift of the sound concept is positively impacted by both traditional and modern ways. On the other hand, students, professors, and candidates in general struggle to connect their understanding of sound to everyday life, have insufficient information, and make mistakes and confusions. In the study conducted by Bolat and Sozen, (2009), Science and Physics Teachers showed low knowledge levels as well as having lots of misconceptions on the sound basic concepts which were determined through questionnaires, analyzed, and interpreted both qualitatively and quantitatively then compared to other studies.

In connection with these misconceptions, the teaching of concepts of sounds must be improved and presented in new ways to lessen these misconceptions. In the study of Eshach, (2016), the Sound Concept Inventory Instrument showed that Grade 8 Taiwanese students hold materialistic views of sound. On the other hand, grade 9 Taiwanese students have a regression in terms of the materialistic view of sound when they do not learn about sound concepts. Therefore, improving the teaching of sound was suggested. The results from the study of Sartoglan (2016) concluded that to change the idea of students about the concept of sound, an experimental-based instruction process should be applied. Furthermore, in

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the study of Arantza, et.al., (2018), even college students struggle with sound understanding. It is important to recognize these issues because they can guide the development of effective teaching and learning methods. Strategic Intervention Material (SIM) is an effective tool for learners experiencing difficulties in Science and Math subjects. According to Limbago and Bastida (2022), senior high school students might learn more by utilizing SIM than by using conventional or traditional methods of education. Acedillo *et. al.*, (2022) said that one of the efficient teaching methods for sciences is the use of strategic intervention material (SIM) because it assists students in enhancing their learning towards the least-learned subjects or competencies. Additionally, using SIM simplifies the lesson, improves the quality of the student's performance, and eventually increases their academic grades. A study by Bastida *et al.*, (2022) revealed that the SIM could aid in elevating the senior high school students' learning development after the pre-test and post-test in physical science among students for the experimental and control groups. Similarly, in the study of Arpilleda, (2021) it is concluded that the strategic intervention materials had a beneficial impact on comprehending the identified least-learned skill, as evidenced by the post-test results of the two groups.

There are existing assessment tools and strategic intervention materials that improve some of the least mastered competencies in science such as the "Sound Concept Inventory Instrument (SCII)" of Yerdelen and Sungur, (2020) which is designed to assess middle school students' sound concepts. Another SIM is the "Pump It Up!" an electronic strategic intervention material that significantly increased the understanding of the lesson in the least mastered competencies in Circulatory and Respiratory systems working with other organ systems of selected Grade 9 learners of Manuel Luis Quezon High School developed by De Jesus, (2019). Lastly, the "Go and Separate" strategic intervention material was designed to improve the decantation and evaporation of Grade VI students at Rizal Central Elementary School, Kapatagan, Digos City for the academic year 2020-2021 toward Quarter I of Science VI's least mastered competencies which enumerating the techniques in separating mixture such as decantation, evaporation, filtering, sieving, distillation, and utilizing magnet include however, in this study, the researcher gave emphasis on evaporation and decantation (Romero, 2021).

This research aimed to develop a strategic intervention material, Guess HuWhat?, in teaching the concepts of sounds to STEM senior high school students. This developed strategic intervention material was evaluated by Science Content Experts and was further utilized by some of the Grade 12 STEM students at Muntinlupa National High School to find out its effectiveness as a learning supplementary material. This strategic intervention material aimed to lessen the misconceptions about the concepts of sounds and improve the students' conceptual understanding of sounds.

METHODOLOGY

Research Design

The study aimed to design a new product and address the problem using the developmental research design. Richey & Klein (2005) described development research as the systematic study of planning, developing, and assessing educational programs, processes, and outputs that must comply with internal consistency and efficiency standards. The study adapted Branch's ADDIE model, which stands for Assess, Design, Develop, Implement, and Evaluate, as the basis for developing the actuarial mathematics course materials. In a study on developing learning materials for actuarial mathematics, Widyastuti and Susiana (2019) stated that the five steps of the ADDIE model were significant in developing the design of the actuarial mathematics module. Mansor, *et al.* (2022) employed the ADDIE model for the mobile learning application of the microeconomics module. The model guided their study's design and prototype apps named "MobiEko Apps." The study's findings revealed that students were pleased with the presentation design, interactivity, visual appeal, navigation, and other aspects of the "MobiEko Apps" mobile learning application's framework for understanding microeconomics.

Material Development

The protocol for the development of the material involves the preparatory stage, game development stage, designing of the character cards, and revision and pilot testing which was adapted from Gutierrez (2014) and Lawsin (2023), see Figure 1. In the preparatory

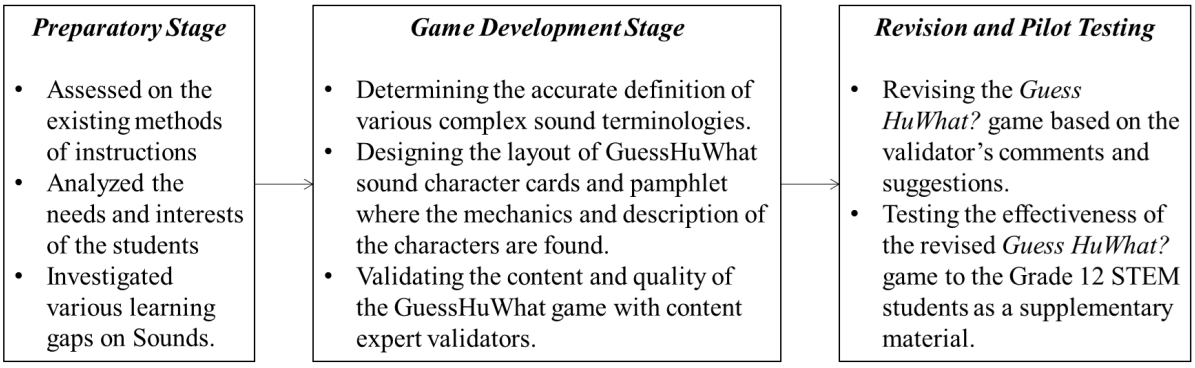

Figure 1: Material Development Protocol adapted from Gutierrez (2014) and Lawsin (2023)

stage, conceptualizing and planning the usage of Guess HuWhat? as a supplementary material through assessing the existing teaching methods, analyzing the needs and interests of the students, and identifying the issues on the teaching and learning process of the topic including the material preparation and other necessary components of the game.

In the game development stage, determination of the accurate definitions of various complex sound terminologies were included in this stage. These definitions were listed, and sound terminologies were assigned to each character to create the layout of the character card. The design of character cards and the pamphlet were created in the Canva app because of its user-friendly features and a wide variety of styles in designing instructional materials. The character card consists of the character's name, the power points of the character, the image of the character, and a word of encouragement from the character. A pamphlet was created where the mechanics, description of the sound terminologies, the power points of the character, the anatomy of the character cards, and the pictures of all the characters are found. The stand of the SIM board game was bought online and the 24 cards that represent the sound concept terms were personalized by the researchers. Each card contains a character name, power points, a character picture, and the character's power description. The game goes like each player receives a board at the beginning of the game with 24 cartoon representations and their corresponding character name, power points, and the character's power description. The desired card is chosen by the player from one of 24 cards that are placed in a separate pile. The first to identify the card that has been chosen is the game's main goal. Asking yes or no questions about traits like, "Does your player have an attribute of sound that determines the intensity of auditory sensation produced.? ", and "Is your player referring to the highness or lowness of the sound? The player turns over the pictures that do

Figure 2: Sample layout of the Character Card; Back Side of the Card (1st); Front Side of the Card (2nd up to the last)

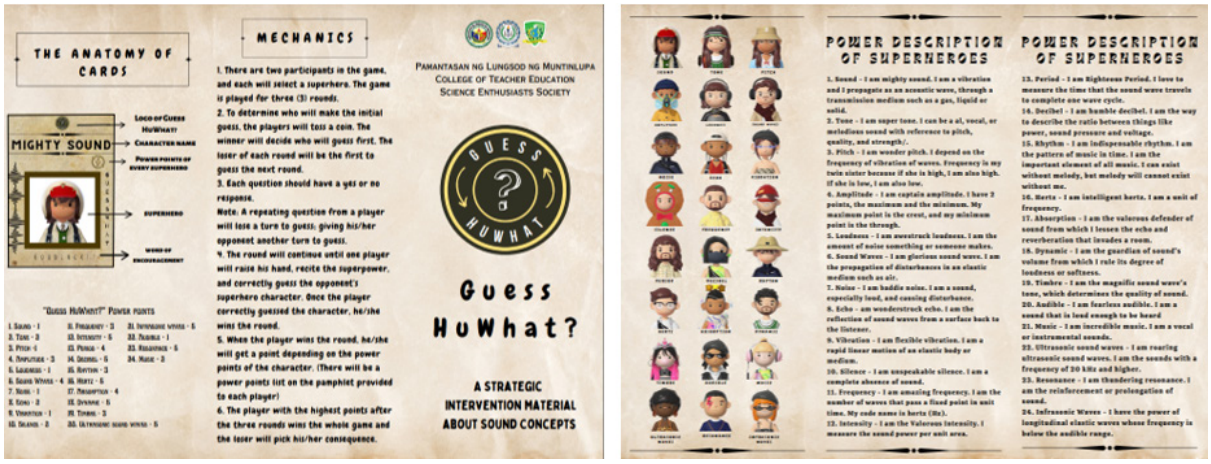

Figure 3: Sample Layout of the Pamphlet; Front Side of the Pamphlet (Left); Back Side of the Pamphlet (Right)

not fit the relevant specifications according to how the opponent responds to each question. The point of each player depends on how complex the sound terminology is defined which is found on the pamphlet. Right after the material design and development, it was validated by the content expert validators using the modified Likert scale that was adapted by Howard, *et al.*, (2003) in her research entitled "Survivor" torches "Who wants to be a Physician?" in the educational game rating war.

In the revision and implementation phase of the material development, the feedback from the content expert validators were considered to improve the overall quality of the Guess HuWhat game and after the revisions were made, it was pilot tested to the Grade 12 STEM students.

Participants of the Study

Due to the proximity of the college to the basic education building of the senior high school, the participants of this study are Grade 12 STEM students from Muntinlupa National High School located in Muntinlupa City. Moreover, there are three (3) evaluators who validated the content of the study. The validators are master teachers and science teachers of the basic education department.

Research Instruments

To obtain the goals of the study, the following research instruments were used namely: (1) the modified Likert scale that was adapted by Howard M, *et al.*, (2003) in her research entitled "Survivor" torches "Who wants to be a Physician?" in the educational game rating war (2) Pretest and posttest which are tests given to the Grade 12 STEM students in science with 15-items tests on the concepts of sound.

Data Gathering Procedure

The strategic intervention material, "Guess HuWhat?" was designed and developed to improve the least-mastered terms of sound concepts among STEM students. The mentioned SIM is a board game adapted to the board game named "Guess Who" wherein it is a two-player guessing game created by Ora and Theo Coster and manufactured by Milton Bradley of Great Britain. During the content expert validation, the numerical evaluation from the Likert scale was tabulated, and the feedback from the validators was summarized and utilized to improve the overall quality of the Guess HuWhat game. The personal information of the content expert validators was not disclosed and only their professional affiliations, educational attainment, and years of teaching experience were published to ensure the qualifications of these experts. In the implementation stage, the students were asked to sign the consent form agreeing that they served as the research participants, and they were informed that all data coming from them would be used for research purposes only. The pretest (T1) was given to the students to identify their initial knowledge, after the usage of the material a posttest (T2) was given to them to measure their understanding of the complex sound terminologies after the intervention was made. At the end of the data collection, all results and analyses were communicated and discussed with the teachers of the participants for their debriefing process. The students' scores were initially tallied and processed in MS Excel 365 version such as descriptive statistics including frequency, percentage, and mean score, as well as inferential statistics such as the Welch F-test and p-value.

RESULTS AND DISCUSSION

Table 1 shows the demographic profile of the respondents who participated in Guess HuWhat? Game. The table has two sections- Gender and Age. The Gender section includes the number of male and female participants. 20 of the 32 responses (62.5%) were female, while 12 (37.5%) were male. The Age section contains information about the respondents' age distribution. The respondents' ages vary from 16 to 18. Out of 32 responders, 9 (28.1%) were 16 years old, 21 (65.6%) were 17 years old, while only 2 (6.3%) were 18 years old. The data is presented in frequency and percentage format in the table, making it easier to understand. It gives an instant summary of the respondents' gender and age distribution, which might be beneficial in measuring the impact of the Strategic Intervention Material intervention on certain student groups. Table 2 summarized the descriptive evaluation of the content-expert validators towards the quality of the Guess HuWhat? game. Based on the summary of the results, the developed Guess HuWhat? A game is evaluated by content-expert validators to be very satisfactory in terms of its criteria on design and layout, content, goals and objectives, playability, and playfulness. In content-expert validation, all items get very satisfactory remarks. The use of board games as a pedagogical technique to reinforce a supportive learning environment is also beneficial in early childhood education (Ramani and Siegler, 2008; Shanklin and Ehlen, 2007). In the first criterion - statements 1, 2, and 3 obtained 4.67 outstanding marks for the first criterion, which deals with design and layout, while statements 4 and 5 obtained 4.33 and 4.00 for very satisfactory results. The average mean score from content expert validators was 4.47,

Table 1: Demographic profile of the respondents

	Frequency	**Percent**
Gender		
Female	20	62.5%
Male	12	37.5%
Total	**32**	**100%**
Age		
16	9	28.1%
17	21	65.6%
18	2	6.30%
Total	**32**	**100%**

Table 2: Descriptive evaluation of content-expert validators

Statements	Mean Scores Content Expert Validators
Design and Layout	
1. The pictures and designs of the Guess HuWhat cards make the game visually appealing.	4.67 (Outstanding)
2. The Guess HuWhat cards' layout is creative, organized, and well-balanced.	4.67 (Outstanding)
3. The overall appearance of the Guess HuWhat game is attractive and caught my attention.	4.67 (Outstanding)
4. The actual product's materials are of high quality but affordable.	4.33 (Very Satisfactory)
5. The product is strong, and it can be used for a very long time.	4.00 (Very Satisfactory)
Average Mean:	**4.47 (Very Satisfactory)**
Content	
6. The directions and rules of the Guess HuWhat game are clear and concise.	4.00 (Very Satisfactory)
7. The Guess HuWhat cards contain correct spelling and are free from grammatical errors.	4.67 (Outstanding)
8. The Guess HuWhat game requires critical thinking and good strategy.	4.00 (Very Satisfactory)
9. The Guess HuWhat game enhances students' conceptual understanding about sound.	4.67 (Outstanding)
10. The Guess HuWhat game used language that is appropriate to the level of understanding of the participants/students	4.67 (Outstanding)
11. The mechanics of the Guess HuWhat game are easy to comprehend and well presented.	4.67 (Outstanding)
Average Mean:	**4.45 (Very Satisfactory)**
Goals and Objectives	
12. The objectives of the Guess HuWhat game are attainable.	4.67 (Outstanding)
13. The Guess HuWhat game engages students to use higher order thinking skills.	3.05 (Satisfactory)
14. The Guess HuWhat Game meets the needs of students from various skills levels.	3.67 (Satisfactory)
15. The Guess HuWhat Game aids to gain a better understanding of sound concepts.	4.67 (Outstanding)
16. The Guess HuWhat Game encourages students to learn more about sound concepts and other science concepts.	4.33 (Very Satisfactory)
Average Mean:	**4.08 (Very Satisfactory)**
Playability and Playfulness	
17.The Guess HuWhat game was challenging but not frustrating.	3.67 (Satisfactory)
18. The Guess HuWhat game provided a good social experience.	4.33 (Very Satisfactory)
19. The Guess HuWhat game was easy to play.	4.33 (Very Satisfactory)
20. The Guess HuWhat Game develop students' communication skills with their classmates/peers	4.67 (Outstanding)
Average Mean:	**4.25 (Very Satisfactory)**
Overall Mean:	**4.31 (Very Satisfactory)**

Note: 4.51-5.00-Outstanding;3.76-4.50-Very Satisfactory;3.01-3.75- Satisfactory; 2.26-3.00 - Below satisfactory; 1.00-2.25 -Poor

which was very satisfactory. This indicates that content-expert validators agreed that the board game's appearance was aesthetically pleasing, organized, well-balanced, attractive, durable, and made of high-quality materials. In the second criterion, statements 6 and 8 obtained a very satisfactory rate, while statements 7, 9, 10, and 11 got outstanding remarks. The average mean score from content validators for the board's content is 4.45, which is very satisfactory. This indicates that the content-expert validators believed that the Guess HuWhat game's content was understandable, concise, and free of grammatical errors, required students to use critical thinking and strategy, and improved their conceptual knowledge of sound concepts. In the third criterion - statements 13 and 14 had mean scores of 3.05 and 3.67, satisfactory, the game's goals and objectives, while Statement 16 earned a score of 4.33, very satisfactory. Statements 12 and 15 both obtained a rating of 4.67 outstanding. The board's goals and objectives got an average mean score from content validators of 4.08, which is very satisfactory. It

reveals that, according to content-expert validators, the Guess HuWhat? The game's goals and objectives were attainable, encouraged students to learn, and helped them develop other various skills. In the fourth criterion - the board's playability and playfulness, statement 17 got a mean score of 3.67 satisfactory, statements 18 and 19 got 4.33 very satisfactory, and statement 20 obtained a mean score of 4.67 outstanding. The board's playability and playfulness got an average mean score from content validators of 4.25, which is very satisfactory. It indicates that, according to content-expert validators, the Guess HuWhat? The game's playability and playfulness were challenging but not frustrating, easy to play, and enhanced student communication skills, resulting in a good social experience. The evaluation obtained an overall mean score of 4.31, which is very satisfactory. It indicates that the content-expert validators are very satisfied with the design and layout, content, goals and objectives, playability, and playfulness of the Guess HuWhat? game. This evaluation corresponds to the systematic review article by Noda *et al.* (2019). The author emphasized that board games can raise participant motivation, enhance interpersonal relationships, and improve knowledge and understanding. Overall, the developed Guess-what games mechanics and content can be great instructional material to increase understanding towards sound terminologies.

Table 3: Difference in the Pretest and Posttest Results of Grade 12 STEM Students

Mean Score		Welch F-value	p-value	Decision on null hypothesis	Remarks
Pre-test	**Post-test**				
8.03 (2.416)	9.69 (2.191)	8.25	0.01	Reject the null hypothesis	There is a significant difference between the pretest and posttest

Note: Standard deviations are in the parentheses

Table 3 shows the summary of the differences between the mean scores of pretests and posttest of Grade 12 STEM students from Muntinlupa National High School - SHS on sound concepts. Grade 12 gained a mean score of 8.03 on their pretest while 9.69 on their posttest. After the Strategic Intervention Material (SIM) was implemented, the researchers found out that there is a significant difference between the pretest and posttest mean scores using Welch F-test as p-value is less than 0.05 ($p<0.05$). It means Guess HuWhat? game can be an alternative educational tool in teaching sound concepts in Grade 12 STEM students. It implies that the developed board game can be a good supplementary material for this topic to enrich students' experience towards learning sound concepts. The researchers created a strategic intervention material and evaluated its efficacy as a supplemental learning tool in this study. The data gathered will assist teachers in designing and developing new game-based activities. Content experts evaluated the board game as highly satisfactory, showing their satisfaction with its appearance and features. The pretest mean score was 8.03, whereas the posttest mean score was 9.69, showing a significant difference between the two scores. These findings confirmed the findings of Bastida *et. al*, (2022), that it revealed that the SIM could aid in elevating the senior high school students learning development after the pre-test and post-test in physical science among students for the experimental and control groups. This implies that the Guess HuWhat? game was successful and effective in teaching sound terminologies to Grade 12 STEM students. The board game might be a useful additional material to increase students' learning experience and a substitute educational tool in teaching this topic. As it is indicated in the results, it can be applied in other basic education schools to gather more empirical evidence towards its effectiveness as a strategic instructional material.

CONCLUSIONS

Based on the data presented, the researchers concluded that the Guess HuWhat Strategic Intervention Material improved grade 12 STEM students' understanding of sound terminologies. By repetitive actions, the developed game-based SIM can be an effective intervention material to deepen students' comprehension of sound concepts and strengthen camaraderie among learners. In line with the conduct of the study, the researchers observed two main factors that teachers should investigate toward their instruction; (1) assessing the learners' needs and (2) capturing learners' interests through developing various engaging activities to address their needs. Therefore, the researchers recommend Guess HuWhat? Game in grade 12 science classes for continuous enhancement of teachers' craft as well as innovation of the game itself. Moreover, it is highly recommended to teachers to design and develop other game-based activities containing concepts that they perceive students are struggling with promoting that learning is indeed fun.

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