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Game-based Learning Using Indigenized Instructional Material in Grade VI Science

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Abstract

This study aimed to develop an indigenized game-based instructional material for teaching Grade VI Science in a public elementary school in Albay, Philippines for SY 2018- 2019, and to determine the effectiveness of game-based learning using the said instructional material. Developmental-descriptive and quasi-experimental methods were employed in this study. Data were gathered using parallel pre-test and post-test and classroom observation. The statistical treatments used were mean percentage score, t-test for paired samples, and effect size. The Portable Science Playhouse (PSP) was improvised through recyclable materials and indigenized through the use of local materials for the mixtures. The lessons on different mixtures and their characteristics using PSP featured game-based strategies, indigenization, learner-centered activities, and students' collaboration. The game-based strategies and indigenized activities were integrated into the following parts of the lesson: engage, explore, explain, elaborate, and evaluate. Both the game-based learning using PSP and the conventional method (expository and demonstration technique) effectively enhanced the proficiency level of the Grade VI pupils in understanding the different types of mixtures and their characteristics. Still, effect size results revealed that game-based learning using PSP was more effective than the conventional method. Further validation lessons using the PSP that feature game-based strategies, indigenization, student-centered activities, and students' collaboration, and the development of more PSPs are highly recommended.

Keywords: *elementary science, game-based strategies, improvisation, indigenization, indigenized game*

Introduction

Science education plays a crucial role in national development. It supports the promotion of science and technology, which the government is mandated to prioritize and sustain (Art. XIV, Sec 10, Philippine Constitution, 1987). At the national level, the delivery of science education is confronted with challenges such as the scarcity of updated and modern science facilities in public schools and poor students' performance in science. In public schools, only one school has a science laboratory in Regions III, IV- A, X, XI, and XII, and in NCR, the ratio is three laboratories for every ten elementary schools (Jalmasco, 2014). The 2019 Trends in International Mathematics and Science Study results on scientific literacy show that only 5% of the students in the Philippines reach the international benchmarks of science achievement (Ina et al., 2020). The poor performance of the students is reflected in the consistent low results of the National Achievement Test (NAT). Albano (2019) reported that the 2018 NAT results in the Grade 6 NAT, which includes science was 37.44% (mean percentage score), the weakest performance in the history of the standardized examination of DepEd.

The support for science education is explicit in the 1987 Philippine Constitution and the Republic Act 10533 - The Enhanced Basic Education Act of 2013. The 1987 Philippine Constitution, Article XIV, Section 10 provides that "the state shall give priority for research and development, invention, innovation, and their utilization; and to science and technology education, training, and services. It shall support indigenous, appropriate, and self-reliant scientific and technological capabilities and their application to the country's productive systems and national life." Meanwhile, the Enhanced Basic Education Act of 2013 mandates the Department of Education (DepEd) "to make curriculum flexible enough to enable and allow schools to localize, indigenize and enhance the

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same based on their respective educational and social contexts." Therefore, the production and development of locally produced teaching and learning materials are encouraged; thus, teachers need to be resourceful enough to localize or indigenize both the lessons and the teaching materials.

Game-based learning is an effective form of instruction to improve students' learning achievement (Hobbs & Yann, 2008; Giannakos, 2013; Papastergiou, 2009; Boeker et al., 2013). Games are learner-centered learning tasks (Peters, 2015; Derakhshan & Khatir, 2015) that have the potential to develop higher-order thinking skills (Hertel & Millis, 2002), build problem-solving skills simultaneously while having fun throughout the process (Mackenty, 2006; Harris, 2009), and lead to significantly higher positive emotion and lower negative emotion (Chen, Husnaini & Chen, 2020). Studies on the use of games reveal a positive effect on the performance of low and middle achievers (Chen, Husnaini & Chen, 2020); increased motivation (Cicchino, 2015; Zhu, 2012; Derakhshan & Khatir, 2015; Cam & Tran, 2017; Bush, 2015), reduced learning anxiety (Cicchino, 2015; Peters, 2015; Rohani, & Pourgharib, 2013; Derakhshan & Khatir, 2015; Cam & Tran, 2017), fostered participatory attitudes of the students (Cicchino, 2015; Peters, 2015; Derakhshan & Khatir, 2015; Bavi, 2018; Bush, 2015; Cam & Tran, 2017).

There are indeed prevailing problems on the lack of science laboratories and poor performance in the science of the students in the public school. Given these challenges, it is essential to recognize the favorable effect on learning of the appropriate use of games and the positive learning results of effective use of simple equipment over the expensive ones (Fraser, Giddings, & McRobbie,1992). Thus, it is compelling to develop alternative materials to facilitate science learning.

This study aimed to develop an indigenized game-based instructional material for teaching Grade VI Science in a public elementary school and determine the effectiveness of game-based learning using the said instructional material in enhancing the pupils' understanding of different types of mixtures and their characteristics. The following questions are answered: 1) What instructional material may be developed integrating the following features; a) improvisation b) indigenization?; 2) What lessons using the developed instructional material may be developed with the following features; a) game-based strategies; b) indigenization; c) learner-centered activities and; d) students' collaboration?; and 3) What is the effectiveness of lessons in enhancing the level of proficiency of the pupils in understanding different types of mixtures and their characteristics?

Theoretical Framework

Indigenized game-based learning is rooted in the constructivist theory of learning. Constructivism is the theory that argues that learners construct knowledge as they experience the world and reflect upon those experiences rather than just passively taking in information (University of Buffalo, 2022). In Piaget's educational theory, the main features relate closely to constructivism. Among the features include: learning as a process of adaptation to environmental stimuli, learning depends upon students' 'hands-on' interactions with objects rather than the transmission of information; and social factors have an essential role in students' knowledge construction (Hargraves, 2017). In brief, Piaget's theory encourages learning through collaboration and interchange among the students themselves. It implies that instruction emphasizes discovery learning, the process of experimentation at all stages, and the construction of knowledge.

Relatedly, the cognitive development theory by Vygotsky argues that social interaction is fundamental to cognitive development and that cognitive abilities are socially guided and constructed (Moore, 2011). The sociocultural contexts shape this cognitive development. Each culture enables us to acquire specific tools that play an integral role in the way children organize and think about the world. Moreover, based on the experiential learning theory by Kolb (1984 as cited by Fry et al., 2004), learning is viewed as a process whereby knowledge is created through the transformation of experience. As argued, the four stages of experiential learning are: 1) concrete experience or "do", 2) reflective observation or "observe", 3) abstract conceptualization or "think", and 4) active experimentation or "plan". Experiential learning means that the learner first actively experiences an activity such as a lab session, then he now reflects on that experience.

Based on the views of Piaget, Vygotsky, and Kolb, learning performance is influenced by cognitive development, experiential learning, and social learning. These are given importance in game-based learning through interactive instructional materials, active learning strategies, and collaboration. Figure 1 shows that the child's cognitive development, social learning, and experiential learning contribute to his holistic development, reflecting his learning performance.

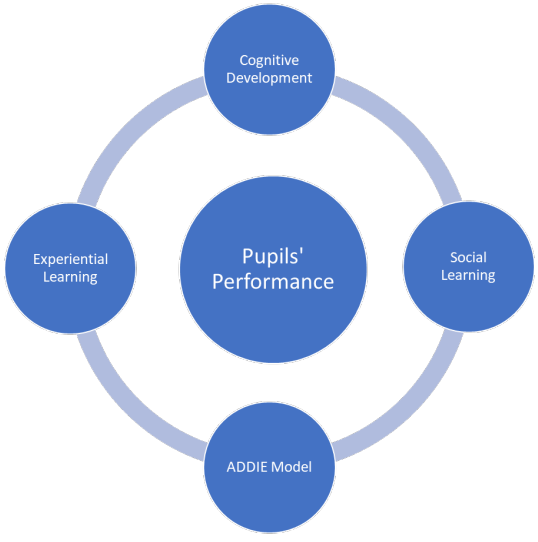

Figure 1 Theoretical Paradigm

Regarding instructional material development, this study adopted the Analyze, Design, Develop, Implement and Evaluate (ADDIE) model. This model allows instructional designers to delve into the needs, learning objectives, and desired outcomes to create more personalized learning resources. Each step has an outcome that feeds into the next step in the sequence. Briefly, this model helps teachers and curriculum developers think through a course's design (University of Washington Bothell, 2019). In this study, the ADDIE model provides the specific steps to design and develop the indigenized game-based instructional materials and the lessons, making the process systematic and rigorous.

Materials and Methods

Research Design. This study employed mixed methods, specifically the developmental-descriptive and quasi-experimental methods. The study was guided by the ADDIE model with the analysis, design, and development phases covered by the developmental-descriptive method and the implement and evaluate stage covered by the quasi-experimental method. The developmental-descriptive method developed the indigenized game-based instructional material in teaching different kinds of mixtures and their characteristics. The method described the indigenized game-based instructional in terms of improvisation and indigenization. This method was used to develop the lessons using the indigenized game-based instructional material and in the description of the lesson plans using the 5Es instructional model in terms of game-based strategies, indigenization, learner-centered activities, and students' collaboration.

The quasi-experimental pre-test-posttest design with a control group was used to determine the effectiveness of the lessons using the indigenized game-based learning on the level of proficiency of the pupils in understanding the different types of mixtures during the First Quarter for Grade VI. The Grade VI classes of the selected public elementary school were the two classes involved in this study. The classes were grouped by the school, and re-sectioning them by any teacher was prohibited. Three experts observed the delivery of each of the five lessons. The treatment refers to the game-based learning using PSP, which consists of five lessons delivered to the experimental group. In contrast, the absence of the treatment referred to as the conventional teaching method was delivered to the control group. The conventional strategy was conducted by having a discussion and demonstration

Table 1 Features of the Intervention for the Experimental and Control Classes

Features	Experimental Group	Control Group
Subject Matter	The same - Different Kinds of Mixtures and their characteristics	The same - Different Kinds of Mixtures and their characteristics
Duration per Session	50 mins	50 mins
Schedule of Classes	8:20- 9:10 AM	7:30- 8:20 AM
Lesson Plan Format	5Es Instructional Model	5Es
Strategies/Techniques Used	PSP- based learning using indigenized games	Expository/ Demonstration Techniques
Materials Used	PSP, indigenized games, roleta, tic tac toe board	Pictures, flashcards
Pupils' Output as Source of Data	Pupils' journal	No Journal

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by the teacher using flashcards or pictures. The features of the lessons delivered to the two groups are presented in Table 1.

Sources of Data. The results of the validated teacher-made pre-tests and post-tests administered in the two classes served as the primary source of data. Other sources of data used were the jurors' comments on the lesson plans, class observations of the teachers, and the journal of the teacher. Relevant information from the books such Science for Daily Use 4, Science and Me, Science, Health and Environment Towards an Active and Responsible Living, Science for Active Learning 7, K to 12 Curriculum Guide and Budget of Work and web source www.rpsec.usca.edu>SISSI>lessons>Gr5Mi were used as bases of the teacher-researcher in developing activities employing game-based strategies and indigenization in the Science lessons. Moreover, the choice of the competencies covered by the lessons was based on the official results of the diagnostic examination conducted by the school.

Subjects and Informants. This study involved the two Grade VI classes in a public elementary school during the school year 2018- 2019. The two classes were pre-contained sections composed of 39 pupils each. These two sections were the first and second sections in the school which were grouped based on the results of an examination administered by the school to ensure homogeneity in the sections. Also, based on the comparison of the pre-test results, the t-test results showed no significant difference between the experimental group's pre-test and the control group's pre-test. The two classes' pre-test results were statistically similar.

The three class observers who are experts were the informants of the study. The three jurors were chosen based on the following criteria: a) have at least ten years of experience as a Science teacher in elementary, b) completed a degree in elementary education, and c) with at least 30 hours of relevant training in the teaching of science.

Instruments. The researcher used parallel pre-test and post-test, class observation guide, and teacher's journals. The pre-test and post-tests, both based on the validated Table of Specifications (TOS), were used to determine the level of proficiency of the pupils in the following competencies: a) describing the appearance of uniform (homogeneous) mixtures; b) describing the appearance of non-uniform (heterogeneous) mixtures; c) classifying mixtures into uniform and non-uniform; d)identifying common household solutions and their uses, and f) identifying the factors that affect the solubility of substances. Both the pre-test and the post-test were multiple-choice types of test items, with 50 items and four choices. These tests underwent content validation by five experts.

Treatment of Data. The quantitative data were interpreted using the following tools: t-test for paired samples, effect size and mean performance score.

The mean performance score was used to describe the level of proficiency of the Grade VI pupils along with the identified competencies. The mean performance score is computed using the formula below:

$$MPS = \frac{MS}{N} \times 100$$

where:

MS is the mean score per skill; N is the total number of items; 100 is a constant value

The pupils' proficiency levels were determined based on the scale used at a public school where the study was conducted, presented in Table 2.

Table 2 Mean performance score and corresponding descriptive equivalent and proficiency level

Mean Performance Score	Descriptive Equivalent	Proficiency Level
92- 100	Full Mastery	Very high proficiency
85-91	Near full mastery	High Proficiency
75- 84	Mastery	Proficient
51-74	Near mastery	Moderate Proficiency
25-50	Low mastery	Low Proficiency
24 below	No Mastery	Very Low Proficiency

The t-test for paired samples was used to determine the significance of difference between the pre and post-test scores of the pupils in the experimental and control group along with the five skills and the whole test. The following formula was used (Ferguson and Takane, 1989).

$$= t = \frac{d}{s/\sqrt{n}}$$

where:

d = mean of the difference; s = standard deviation of the difference

Since the result of the t-test for paired samples (pretest-posttest performance) had yielded significant results both for the experimental and control group, the effect size was computed to see how substantially different they were. Effect size is calculated using Cohen's d, with the following formula:

$$d = \frac{\bar{d}}{s_d}$$

where:

d = mean of the difference; s = standard deviation of the difference

The effectiveness (E) of the game-based learning using PSP over the conventional method of teaching was determined using the following formula:

$$E = \frac{(d_e - d_c)}{d_c} x100$$

where:

de= effect size of the experimental group
dc= effect size of the control group

The qualitative data from the observation were analyzed using manual coding. The data were tallied, then each entry was read and reread. Common data then were grouped and interpreted to substantiate the statistical results.

Results and Discussion

The use of appropriate and engaging instructional materials is one of the essential ingredients of effective teaching. These serve as essential tools in learning every subject and allow the students to interact with words, symbols, and ideas in ways that develop their abilities in reading, listening, solving, viewing, thinking, speaking, writing, and using media and technology (Bukoye, 2019). With these instructional materials, the teacher can provide sufficient, appropriate,e and varied instructional materials to concretize and substantiate learning.

Instructional Material in Grade VI Science Integrating Improvisation and Indigenization

The indigenized game-based instructional material developed is called the Portable Science Playhouse (PSP), a three-dimensional improvised instructional material measuring 1.84 m x 2.32 m and designed like a house (Figure 2). Among its parts are the kitchen, dining area, bathroom, bedroom, and living area, each part structured in a shoebox, veranda, storeroom, roof, and lawn.

The PSP features improvisation. In this study, it means using local and recyclable materials to develop instructional material such that these materials will serve a different purpose than their original use. These are the file boxes, shoe boxes, medicine bottles, mineral water bottles, plastic bottles, vacutainers, bottle caps, and photo paper. The developed PSP was used in teaching concepts about mixtures.

Indigenization was integrated into the PSP using materials such as mongo seeds, rice hulls, sawdust, corn seeds, ginger powder, sand, pebbles, and others, all of which are local materials. These materials were placed in vacutainers to show different types of mixtures and in the medicine bottles to contain substances that the pupils will use during the lesson.

Parts of the PSP

The main parts of the PSP are the kitchen, dining area, bathroom, bedroom, and living area. Each part of the house is structured in a shoebox. Other parts of the PSP are the veranda, storeroom, roof, and lawn.

The kitchen part of the playhouse is structured with a sink and cabinet. Properly labeled replicas of the solution used in this part of the house made from Styrofoam were pasted on the cabinet and the sink. Under the sink and cabinet are small plastic containers containing real solutions found in the kitchen. These are correctly labeled for easy identification. Sample

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empty sachets of solutions used in cooking were also placed in one kitchen corner.

Another part of the playhouse is the dining area. A dining set toy was used so that it would appear realistic. A cabinet in the dining area contains cut-out styrofoam, representing the common household solutions used in this part of the house. Just like the kitchen, the dining area also has small plastic containers containing mixtures and empty sachets of solutions usually used in eating.

The bathroom is the third main part of the PSP. Cleaning materials in the form of toys were used to appear more realistic. The bathroom cabinets also have a replica of solutions, real solutions, empty sachets, and labels of solutions commonly used in this part of the house.

The bedroom is structured using spare cardboards and toys. Like the three other parts of the PSP, it contains replicas of the solutions, real solutions and empty sachets, and labels of common household solutions used in this part of the house.

The kitchen, dining area, bathroom, and bedroom contained replicas of solutions, real solutions, empty sachets, and labels of solutions. Replica of real solutions made of Styrofoam was made so that the pupils would easily recognize them as household solutions. Since the real solutions were not contained in their real containers due to limited space, empty sachets and labels of solutions guide the pupils in identifying the use/s of a particular household solution, thus, significant in carrying out the competency on identifying the common household solutions and their uses.

The veranda is located on the second floor of the house. It has balusters in the form of vacutainers. These vacutainers contain sample mixtures made from combined local substances. This design lets the pupils identify the type of mixture inside the vacutainer for the competencies; a) identifying uniform and non-uniform mixtures and; b) describing the appearance and uses of uniform and non-uniform mixtures.

The storeroom, also located on the veranda, is made from a used cellphone box. It stores disposable spoons, extra mixing cups, chamois, clips, and others.

The roof of the house was made of plywood. It was made detachable for easy exploration of the inside of the house. It was made as a design only to make the PSP appear more realistic.

The lawn of the house was designed with a landscape surrounded by a fence in the form of medicine bottles. These bottles contain substances usually used in the house and the community. Each corner of the fence is a post with a half-cut mineral bottle representing the

Figure 2 The Portable Science Playhouse (PSP): An Indigenized Game-Based Instructional Material in Grade VI Science
(A- roof, B- storeroom, C- veranda balusters, D- mixing cup, E- mixing post, F- storage cup, G- fence, H- task card pocket)

surrounding light posts. This part of the house was specifically designed for forming mixtures.

Through the pull-out post, the pupils could combine the substances in the mineral water bottle called the stirring cup. Once the group is done combining one specific mixture, the cap of the stirring cup may be removed to release the used/ observed mixture.

Lessons Using the Portable Science Playhouse

Table 3 shows the matrix of the lessons and the specific activities or games used in each phase of the lesson, engage, explore, explain, elaborate, and evaluate. Each lesson integrates the following features: a) game-based strategies; b) indigenization; c) learner-centered activities; and; d) students' collaboration through the games and activities in the different points of integration.

Table 3 Lessons and activities used in the different phases of the 5Es model

Lesson No.	Lesson Topic/ Title	Learning Competency/ies	ACTIVITIES FOR EACH PHASE				
			ENGAGE	EXPLORE	EXPLAIN	ELABORATE	EVALUATE
1	Homogeneous Mixtures	a. Identify uniform (homogeneous) mixtures b.Describe the appearance and uses of a uniform (homogeneous) mixture	Showing a picture of *kutsinta* Brainstorming on how a kutsinta is made	Group Activity (Forming homogeneous mixtures using the substances assigned to the group)	Presentation/ Discussion of Output/ Findings by the group rapporteur	Playing *PINOY HENYO*	Playing *Paikutin ang Roleta*
2	Heterogeneous MIxtures	a. Identify non-uniform (heterogeneous) mixtures b. Describe the appearance and uses of non-uniform (heterogeneous) mixtures	Forming puzzles through *Kilala Ko To* Game	Group Activity (Forming heterogeneous mixtures using the substances assigned to the group)	Presentation/ Discussion of Output/ Findings by the group rapporteur	Additional information provided by the teacher Playing TIC TAC TOE Game	Formative test (Sentence Completion) Decorate a Bottle Activity
3	Classifying Mixtures	Classify mixtures into uniform and non-uniform	Identifying the type of mixture shown in the picture by standing or sitting.	Playing Scavenger Hunt Game	Presentation/ Discussion of Output/ Findings by the group rapporteur	Playing *Pamilya Tayo* Game Bicolanos' Favorites Activity	Formative Test (Classifying the types of mixtures by writing the name of the mixture in the proper column.
4	Common Household Solutions	Identify common household solutions and their uses b. Give examples of common household solution	Reveal the Message Activity through Number Clues Demonstration on Natural Deodorant Making	Playing *Bahay Bahayan*	Presentation/ Discussion of Output/ Findings by the group rapporteur	Additional information provided by the teacher Playing *Ako Ba Ito* Game	Matching the common household solution with its use. Playing *JACK en POY*
5	Factors Affecting Solubility of Substances	Identify and describe the factors that affect the solubility of substances	Metacognition Activity Playing *Purutukan Ki Lobo*	Group Activity (by station)	Presentation/ Discussion of Output/ Findings by the group rapporteur	Additional information provided by the teacher	Playing Mt. Mayon HIking

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Table 4 Description and mechanics of the indigenized games

Name of Indigenized Games	Description and Mechanics of the Games
Penoy Henyo	In *Pinoy Henyo* Game, some pupils acted as *henyo* and the class as prompters. The teacher wrote an example of a homogeneous mixture in the meta card. The *henyo* should guess the homogeneous mixture written on the meta card with the help of the prompters by asking if it is used as food, jewelry, drinks, and others. The prompters were only allowed to answer OO o HINDI only. The *henyo* was given 3 minutes only to guess. The henyo with the greatest number of words correctly guessed was declared the winner.
Paikutin and Roleta	This is a game played by a partner using *roleta*. A *roleta* is made of a wooden wheel with an arrow hand at the center that stands on a platform. This is played by spinning the wheel. When it stops, the letter where the arrow hand points indicate the PSP mixture to be identified. Each correct answer earns one (1) point. The team with the highest score is declared the winner.
Kilala Ko To	This is a puzzle game. Each group was given an envelope containing pieces of the puzzle. Upon signal, the group assembled the pieces to form one piece puzzle. The first group that was able to write immediately and correctly the revealed mixture in the puzzle was declared the winner.
Tic Tac Toe	This is a board game played by two teams, boys versus girls. The board consists of nine (9) cut-out pictures of Bicol foods such as *Pinangat*, Bicol Express, Pilinut Candy, *Ginatan*, *Kutsinta*, *Sili* Ice Cream, *Binutong*, *Pinuso* and *Linupak*. These were arranged in a tiled pattern in front, with a corresponding letter at the back of each picture. This is played by picking the picture of the food choice and seeing the letter at the back of the chosen picture. The team will get the mixture in the PSP, which is labeled with the same letter. A task shall be followed/ answered. If answered correctly, the team will pick another picture of his choice and do the same. The first team to give three (3) correct answers either horizontally, vertically, or diagonally will be declared the winner.
Scavenger Hunt	This is a game played by six groups. Each group has a scavenger representative. Upon signal, the scavengers get from the PSP some mixtures and bring them to the group. The group classifies the mixtures by listing the mixture in its proper column. The group is given 3 minutes only to hunt mixtures. The group with the greatest number of correct answers will be the winner. Through this game, the pupils were challenged to classify correctly the mixture written in each meta card by listing each mixture on the appropriate column in the table.
Pamilya Tayo Game	This is a game adopting the "The Boat is Sinking" game. The teacher gives the class meta cards where each pupil writes one example of a mixture. Upon signal, "The boat is Sinking, save your family," each pupil must join other classmates with the same type of mixture. When the teacher says STOP, she will check if each pupil is correctly grouped. The group with many incorrect answers loses. It aimed to let the pupils give an example of a mixture and be able to classify the given example as to its type by joining the group where it should belong.
Bahay- Bahayan	This game is played using the PSP, which serves as the *bahay*. The group will choose their favorite part of the house and detach it from the PSP. The task is to identify the common household solutions found in the part of the house they have chosen. The group with the biggest number identified is the winner.
Jack en POY	This is a game played by partner with two teams. (Boys vs. Girls) Whoever wins will choose either SOLUTION or USES. If he selects a solution, he will give an example of the solution, and the opponent must give the uses of the solution named and vice versa. The team with the greatest number of winners was declared the winning team.
Purutukan Ki Lobo	This game is played by four (4) teams with 9- 10 members. On the board are columns for the factors affecting the solubility of substances. Upon signal, the player of each team will get a balloon, go to the monobloc chair assigned to the team, deflate the balloon by sitting on it, read the writings on the paper inside the balloon, tell the answer and post the paper on the board under its appropriate column. As soon as the player finishes posting on the board, he shall tap the next player. The first team to finish shall gain 5 points. Each correct answer corresponds to one point. The team who gets the highest score wins.
Mt. Mayon Hiking	This game uses a chart that shows an illustration of Mt. Mayon with its sub-camps and a flag on its peak. The game is played by a team that starts from the starting line. Then the teacher read aloud each question. Each correct answer of the team brought them to each camp. The team who reached the peak first was declared the winner.

Game-based Strategies Used in the Lessons

Game-based learning using the PSP used games as a teaching strategy. These games were the games usually played in the locality. Pinoy Henyo, Paikutin ang Roleta, Kilala Ko To, Tic Tac Toe, Scavenger Hunt, Pamilya Tayo, Bahay- Bahayan, Ako Ba Ito, Jack-en Poy, Purutukan Ki Lobo and Mt. Mayon Hiking were the games used during the lesson.

Games as a teaching strategy can lead to learners' positive feelings toward game-based learning (Pinder, 2016) and positive impacts on the teaching-learning processes (Boeker et al., 2013; Chen, Husnaini & Chen, 2020; Giannakos, 2013; Hobbs & Yann, 2008; Papastergiou, 2009; Pinder, 2016), have the potential to develop higher-order thinking skills (Hertel & Millis, 2002), build problem-solving skills simultaneously while having fun throughout the process (Mackenty, 2006; Harris, 2009), and lead to significantly higher positive emotion and lower negative emotion (Chen, Husnaini & Chen, 2020). Studies on the use of games reveal a positive effect on the performance of low and middle achievers in the basics of chemical elements and compounds (Chen, Husnaini & Chen, 2020). Literature likewise shows that game-based learning is an effective form of instruction to improve the learning achievement of elementary pupils (Hobbs & Yann, 2008), middle school students (Giannakos, 2013), high school students (Papastergiou, 2009), and even undergraduate students (Boeker et al., 2013).

Integrating Indigenization in Lessons

Indigenization was integrated into the lessons in terms of materials used, games and activities, local products, local culture, and local context. Locally available materials such as mongo seeds, corn seeds, rice hull, ginger powder, sawdust, and others were used. Loca; games played in the Bicol Region were also used in the lessons such as Roleta game, Pamilya Tayo Game, Bahay- Bahayan and Jack en Poy, Local products such as kutsinta, salabat, palamig, sago't gulaman juice, bukayo and mazapan de pili, and pictures of local products such as pinangat, Bicol Express, pilinut candy, ginataan, and others were introduced. The use of local culture, such as valuing the family and local tourist spot (Mt. Mayon), were also used in the games. The game-based learning using PSP made learning more relatable, thus meaningful to the pupils based on the observers' feedback and informal interview with the pupils. Favell (2015) found the use of indigenization in music and art effective. Moloi et al. (2021) reported that indigenous games improved learners' creativity and imagination during eLearning mathematical word problems. The result, therefore, implies that teachers must consider indigenization in the lessons through the materials being used, activities, and context to make learning more meaningful.

Learner-Centered Activities in the Lessons

Learner-centered activities or activities that are appropriate and are within the level of the learners which they accomplish were given in the different phases of the lesson, namely, engage, explore, explain, elaborate, and evaluate. These activities were: brainstorming, puzzle activity, differentiated group activity, group activity by station, reporting of group findings, playing Tic Tac Toe game, decorate a bottle activity, Reveal the Message through number clues, playing Bahay-bahayan and Jack- en- Poy, Purutukan ki Lobo and Mt. Mayon Hiking game. These activities given allowed the pupils to perform the tasks themselves rather than the teacher. These game-based activities require actual student participation with the teacher as facilitator; thus, active engagement is expected.

Students' Collaboration

This feature of PSP- based learning allows the pupils to accomplish tasks through shared ideas, effort, and resources within the group. Therefore, because all the lessons developed have the explore part where pupils carry out hands-on activities in groups, students' collaboration was observed. Other phases of the lesson also developed students' collaboration. Among these were the games played either by partner, group, or team in the different phases of the lesson. One class observer noted that "the learners' participation was maximized." Another class observer commented that "pupils collaboratively performed the tasks given and were excited to win the game." Another class observer mentioned that "the pupils' participation was maximized throughout the lesson'. In game-based learning, the students enhance their ability to collaborate with peers. Students with a positive collaboration attitude have greater creative self-efficacy (Kong et al., 2018). There is then a need to encourage students' collaboration during the teaching-learning process because it develops the ability of the pupils to interact with other people, express ideas comfortably, and contribute personal effort toward the group's goal.

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Effectiveness of the Lessons in Grade VI Science in Enhancing Pupils' Proficiency Level in Different Types of Mixtures and their Characteristics

The effectiveness of the lessons developed using the Portable Science Playhouse was measured as to how it has enhanced pupils' proficiency level in understanding the different types of mixtures and their characteristics. The level of proficiency in understanding the different types of mixtures and their characteristics was gauged through pre-test and post-test.

Five least mastered skills were identified under the competency in understanding the different mixtures and their characteristics based on Grade VI diagnostic test results during the first quarter of SY 2018- 2019 of a public elementary school. These skills were: (1) describing the appearance and uses of uniform (homogeneous) mixtures; (2) describing the appearance and uses of non-uniform (heterogeneous) Mixtures; (3) classifying mixtures into uniform and non-uniform; (4) identifying common household materials and; (5) identifying the factors that affect the solubility of substances. These were the skills of the Grade VI pupils, which were found below the mastery level of 75%, and were the skills covered in this study.

As shown in Table 5, the pre-test results for both the control and experimental group show that the pupils had near mastery for skill 1, low mastery for skills 2 and 5, and no mastery for skills 3 and 4. Overall results show no mastery. Meanwhile, the post-test results for both groups show that the pupils had near mastery of skills 1, 2, 3, and 5. For skill 4, the pupils in the experimental group had near mastery, while those in the control group had low mastery. Overall, the pupils had near mastery of understanding different types of mixtures and their characteristics.

The results reveal the lack of mastery of the pupils in understanding different types of mixtures and their characteristics, thus confirming the results of the 2019

Table 5 Level of Proficiency of the Grade VI Pupils in Different Types of Mixtures and their Characteristics

Skills		Group Mean Score	Pre-test Results			Posttest Results		
			Mean Score	Proficiency Level (%)	Mastery Level	Mean Score	Proficiency Level (%)	Mastery Level
1	Describing the appearance of uniform (homogeneous) mixtures (n = 8)	Exp	4.3	53.21	Near Mastery	5.7	71.47	Near Mastery
		Con	4.4	54.49	Near Mastery	5.3	66.35	Near Mastery
2	Describing the appearance of uniform (heterogeneous) mixtures (n = 8)	Exp	3.5	43.91	Low Mastery	5.6	69.55	Near Mastery
		Con	3.5	43.91	Low Mastery	4.7	59.29	Near Mastery
3	Identifying the factors that affect the solubility of a substance (n = 14)	Exp	5.8	41.21	Low Mastery	8.7	62.45	Near Mastery
		Con	4.7	33.33	Low Mastery	7.1	50.37	Near Mastery
4	Classifying mixtures into uniform and non-uniform (n = 8)	Exp	1.9	24.04	No Mastery	4.2	52.88	Near Mastery
		Con	1.7	21.79	No Mastery	3.2	39.74	Low Mastery
5	Identifying common household solutions and their uses (n = 12)	Exp	2.4	20.30	No Mastery	8.0	66.88	Near Mastery
		Con	2.1	17.09	No Mastery	7.0	58.55	Near Mastery
	Overall (n = 50)	**Exp**	**17.9**	**35.79**	**No Mastery**	**32.3**	**64.56**	**Near Mastery**
		Con	**16.3**	**32.67**	**No Mastery**	**27.3**	**54.62**	**Near Mastery**

Table 6 Effectiveness of the game-based learning using PSP in enhancing the skills under understanding different types of mixtures and their characteristics

Skills	Group	Mean of difference	The standard deviation of the difference	Comp *t* value	*p*-value	Sig	Effect size (d)	Effectiveness of the game-based learning using PSP (%)
1. Describing the appearance of uniform (homogeneous) mixtures (n = 8)	Experimental	1.5	1.5869	5.752	0.000	Significant	0.9210	38.99
	Control	0.9	1.4318	4.138	0.000	Significant	0.6626	
2. Describing the appearance of uniform (heterogeneous) mixtures (n = 8)	Experimental	2.1	1.8771	6.824	0.000	Significant	1.0928	87.20
	Control	1.2	2.1084	3.645	0.001	Significant	0.5837	
3. Identifying the factors that affect the solubility of a substance (n = 14)	Experimental	3.0	2.3225	7.998	0.000	Significant	1.2807	49.19
	Control	2.4	2.7779	5.361	0.000	Significant	0.8584	
4. Classifying mixtures into uniform and non- uniform (n = 8)	Experimental	2.3	2.5459	5.661	0.000	Significant	0.9064	60.48
	Control	1.4	2.5422	3.527	0.001	Significant	0.5648	
5. Identifying common household solutions and their uses (n = 12)	Experimental	5.6	2.5102	13.907	0.000	Significant	2.2268	21.73
	Control	5.0	2.7192	11.424	0.000	Significant	1.8293	
6. Whole test (n = 50)	Experimental	14.4	6.1968	14.496	0.000	Significant	2.3213	49.60
	Control	11.0	7.0729	9.690	0.000	Significant	1.5516	

TIMMS showing the poor scientific literacy of the students in the Philippines (Ina, Mullis, Martin, Foy, Kelly & Fishbein, 2020). Although it is interesting to note the increase in the proficiency levels of the pupils, the issue of improving the scientific literacy of the pupils remains a pressing concern that can be addressed by improving instructional delivery, and instructional materials, among others. As argued by Bukoye (2019), instructional materials are essential tools in learning that allow the students to interact with words, symbols, and ideas in ways that develop their abilities in reading, listening, solving, viewing, thinking, speaking, writing, using media and technology, and consequently lead to improved learning.

As shown in Table 6, the t-test results from the test scores of both the experimental and control groups significantly improved after the intervention in all five skills. The results mean that both the game-based learning using PSP and the conventional method (using expository and demonstration techniques) effectively enhance the pupils' understanding of different types of mixtures and their characteristics. Since the result of the t-test for paired samples (pretest-posttest performance) yielded significant results both for the experimental and control groups, the effect size was computed to see how substantially different they are. The overall effect size for the experimental group was 2.3213 and 1.5516 for the control group. The effectiveness (E) of the game-based learning using PSP

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over the conventional method of teaching for the five skills are as follows: skill 1 38.99, skill 2 – 87.20, skill 3 – 49.19, skill 4 – 60.48, and skill 5 – 21.73 while the overall result was 49.60.

Results imply that the use of the conventional teaching strategy should not be eliminated but can be further enhanced by injecting other strategies like the use of PSP and its features to make learning more effective. Besides, the literature review shows that simply changing teaching methods without concern for how methods are implemented has little potential for raising overall achievement levels (Schwerdt & Wuppermann, 2010). In particular, the results indicate that the game-based learning using the PSP, which features improvisation and indigenization, was more effective than the lesson using the conventional strategy with flashcards and pictures. These results imply that the conventional methods are not anymore adequate to meet our needs, and these new ones can enhance the possibility of learning (Sabater, 2011).

The effectiveness of the game-based learning using PSP supports the findings showing that game-based learning improves the learning achievement of elementary pupils (Hobbs & Yann, 2008), middle school students (Giannakos, 2013), high school students (Papastergiou, 2009), and even undergraduate students (Boeker et al., 2013). Furthermore, the present study validates the findings that games and game-based learning have the potential to develop higher-order thinking skills (Hertel & Millis, 2002) and build problem-solving skills simultaneously while having fun throughout the process (Mackenty, 2006; Harris (2009). The positive outcome of the use of game-based learning using PSP in elementary science confirms that the use of games in learning has a positive effect on learning performance (Ramirez, 2006) among low and middle achievers ((Chen, Husnaini & Chen, 2020). However, the present findings contradict the findings of Wrzesien and Raya (2010) that there was no evidence to show that the game led to significant learning advancements over the traditional class.

Conclusion

Game-based learning is an effective form of instruction to improve students' learning achievement (Hobbs & Yann, 2008; Giannakos, 2013; Papastergiou, 2009; Boeker et al., 2013). The effective use of simple equipment over the expensive ones results in positive learning (Fraser, Giddings, & McRobbie,1992), while indigenization is an effective teaching-learning strategy (Favel et al., 2015). With the observed scarcity of laboratory equipment in public elementary schools in the Philippines, this study aimed to develop an indigenized game-based instructional material for teaching Grade VI and to determine the effectiveness of game-based learning using the said instructional material in enhancing the level of proficiency of the pupils in understanding different types of mixtures and their characteristics. This study produced indigenized game-based lessons using the improvised Portable Science Playhouse (PSP), which can contribute to the literature on using simple equipment and instructional games as tools for teaching and learning and indigenization materials and lessons.

The PSP is an alternative improvised and indigenized game-based learning material for teaching the topic mixtures and their characteristics in Grade VI Science. The lessons were developed using the PSP and integrating game-based strategies, indigenization, learner-centered activities, and collaborative learning. Students' collaboration was effectively used in teaching the different kinds of mixtures and their characteristics. Both the lessons using game-based learning using PSP and the lessons using the conventional (expository and demonstration technique) effectively enhanced the pupils' proficiency level in understanding the different types of mixtures and their characteristics. However, the former was more effective in enhancing the level of proficiency of the pupils than the latter. The use of the PSP in the lessons, which feature game-based strategies, indigenization, student-centered activities, and students' collaboration which are considered simple, practical, and effective innovation, may be used by both teachers and pre-service teachers for further validation and refinement. Developing more PSPs for dissemination to teachers in other schools is highly recommended.

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