The usefulness and impact of ChemSaga as a tool to teach periodic table of elements

Kevin Clyde A. Ong[1] and Joji D. Linaugo[2]
[1]*Bacolod City National High School, Bacolod City, Philippines*
[2]*Department of Education – Division of Negros Occidental, Bacolod City, Philippines*

ABSTRACT

This paper determined the usefulness and impact on students' academic achievement of an educational board game. Researcher-designed "ChemSaga" reinforce the conceptual topics of Periodic Table of Elements. The game tests learned skills and concepts regarding history of the Periodic Table of Elements, positions of elements that are found in the Periodic Table of Elements, and periodic trends. The experiment was implemented to 44 Grade 8 students of Mansilingan Agro-Industrial High School. The students' level of satisfaction and acceptability to the game as an educational tool were evaluated using a 5-point Likert-type scale. The results showed that students well accepted the game "ChemSaga." The distribution of students' responses in the survey is the majority "satisfactory" score in both students' level of satisfaction and level of acceptability. Findings also showed that there is no significant difference in the students' academic achievement after exposure to educational board game across different sexes. Therefore, the game is applicable regardless of the students' sex. The game successfully helped improve students' academic performance in reinforcing their background and foundations in the Periodic Table of Elements, providing enjoyable activities in the classroom and enabling the socialization of the students.

***Keywords**:*
Science education
Chemistry
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Educational Board Games
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Introduction

Chemistry, by its nature, is highly conceptual and demands the bringing together of understandings of those concepts in a meaningful way. It is for that reason that Chemistry is not an easy task for students (Cook, Kennedy, & McGuire, 2013). Most learning difficulties are due to the particular perspective of Chemistry that in many ways oppose spontaneous and everyday views of learners (Treagust, 2000). According to Silva (2015), Chemistry's specific vocabulary, abstract concepts, model interpretations, and mathematical skills made the learning process a real challenge for teachers and students at any level. Students ought to deal with procedural knowledge and concepts like equations, nomenclatures, bonding, and functions (Marais & Combrinck, 2009; Marasigan & Espinosa, 2014). Due to its massive call,

Franco-Mariscal (2014), reported that Chemistry is often not well appreciated by high school students. However, we cannot deny the fact that the knowledge gained through Chemistry allows us to make informed decisions about our future (American Chemical Society [ACS], 2015). According to ACS (2012), one of the most important ideas in Chemistry is that what people view and perceive in the macroscopic world is a result of interactions at the atomic level. This statement agrees with what Sirhan (2007) said that one of the essential characteristics of Chemistry is the established interplay between the macroscopic and microscopic levels of thought. Hence, no matter how complex Chemistry is, students should acquire appreciation towards the subject.

One specific topic that students find it difficult to understand is the topic of the periodic table of elements. Their major drawback is learning the periodic table by memorizing, as they see it uninteresting (Marti-Centelles & Rubio-Magnieto, 2014). It agrees with what Bullock (2013) cited that memorization is a counterproductive practice and does not lead to deep learning. Thus, the idea of games application as a motivational tool has been brought up to make learning fun (Kirriemuir & Mcfarlane, 2007). Motivation to learn science benefits all students by fostering their scientific literacy, which is the capability to understand scientific knowledge, identify critical scientific questions, draw evidence-based conclusions, and make decisions about how human activity affects the natural world (Bryan, Glynn, & Kittleson, 2011).

The development towards the increasing use of games for teaching has significant implications for understanding difficult concepts (de Freitas & Oliver, 2006; Antonio Joaquín Franco-Mariscal, Martínez, & Márquez, 2012; Kinzie, 2015). These games include virtual and use of physical objects that address specific educational needs such as manipulation of physical objects, symbolic representations, and physical interactions (Melero & Hernández-leo, 2014). Moreover, Antunes, Pacheco, and Giovanela (2012) made it clear that games are educational when they develop cognitive and operational abilities such as problem solving, perception, creativity, and reasoning, which are essential for knowledge construction. Marti-Centelles and Rubio-Magnieto (2014) stated that games are promising teaching alternative as they can be a tool for teaching specific topics, and this allows students to learn in a fun way compared to the traditional lecture format. Aside from providing means of reviewing material, using an educational game as a tool in the classroom brings students to an atmosphere that would encourage them to participate and strategize making them more active and more cooperative (Koether, 2003). Several authors have developed educational games or puzzles aimed at helping students to learn, understand, and apply basic chemical concepts in a challenging, interactive format (Franco-Mariscal et al., 2012). Such authors – Russell (1999), Denny (2000), Pieroni (2000) along with their co-authors have reported that those games were active with successful pedagogical results. Game-based training perceived as enjoyable by the student will potentially allow themselves to scale initial hurdles to acceptance and usage, create higher-level intrinsic motivation, and lead to sustained usage behavior (Williams-Pierce, 2011). Also, Tanni (2012) remark that educational games can drive a child to be focused because they are patient while waiting to achieve getting to the next level. Therefore educational games can hold students' attention, can improve positive peer relationships, and can lead to a deeper understanding of the material and more advanced problem-solving skills in a fun way (Bayir, 2014; Moreno, Hincapié, & Alzate, 2014; Spandler, 2016). Wilson (2014) stated that it is well understood that when learning turns into a game, it can lead to better engagement and contribute to the mastery of the subject matter. Through this, long-term memories are achieved because of

the presence of emotion, concentration, and focus on these activities.

Games have been demonstrated to be highly effective educational tools in many science fields (Franklin, Peat, & Lewis, 2003; Kumar & Lightner, 2007). In recent years, many educational games have been incorporated into teaching to improve students' academic performance such games are biochemistry word searches, (Helser, 2003) Sudoku puzzles, (Crute & Myers, 2007) online spectroscopy game, (Bradley, Lancashire, Lang, & Williams, 2009) and puzzles utilizing named reactions in Organic Chemistry (Erdik, 2005). Locally, chemistry games such as ChemTrump, ChemSearch, ChemPuzzle, ChemFactory, and ChemSquabble were invented and introduced by Azucena-Topor. These games were used to establish students' interest and motivation in chemistry.

In this paper, the researchers introduced a new board game called ‘‘ChemSaga" that relates to concepts on the history of the periodic table, position of elements, and trends in the periodic table of elements. The game was implemented to Grade 8 students of Mansilingan Agro-Industrial High School (MAIHS). The goal is to reinforce the conceptual topics with the students. The effectiveness of ChemSaga as an educational tool was evaluated by determining the level of satisfaction and acceptability and mean gain of the students. The game can be used as a resource for teaching groups and periods to Grade 8 students and designed to promote active learning of the positions of elements, as well as the aspect of their uses and importance to modern society. The inclusion of ChemSaga into Chemistry curriculum at the secondary level has the potential to enhance the development of student interaction, and it may repay the difficulties students face in acquiring knowledge of element positions, properties, and trends.

This study aimed to determine the effectiveness of ChemSaga in reinforcing conceptual topics of Periodic Table of Elements with the Grade 8 students of MAIHS for School Year 2017-2018. Specifically, the study sought to answer the following questions: (1) What is the level of satisfaction of students in playing ChemSaga? (2) What is the level of acceptability of students in playing ChemSaga? (3) What is the level of students' academic achievement after exposure to the educational board game when taken as a whole and grouped according to sex? (4) Is there a significant difference in the students' mean gain academic achievement after exposure to educational board game when taken as a whole and grouped according to sex?

Framework of the Study

This study is anchored on the theory of constructivism, particularly the method of play. One of the most influential constructivists is Jean Piaget. Piaget (1964) deemed that learning is provoked by situations such as psychological experimenter or by a teacher concerning some academic point. He believed that knowledge is not information to be carried at one end, and encoded, memorized, retrieved, and applied at the other end. On the opposite, education is an experience that is acquired through interaction with the world, people, and things. Piaget (1962) believed that a person's environment plays a significant role in his development.

Play serves different purposes at different ages. Piaget specified that there are three types of play namely: sensorimotor play, symbolic, and games with rules. Among the types of play, he noted that games with rules are characterized by competition and established control. Thus, Piaget (1962) viewed games with rules as an effective way of developing knowledge because learners need to acquire balance in the face of different standpoints on how games should be played.

Vygotsky (1966) is another constructivist who strongly supports the importance of the application of games in

lessons. He understood that games with rules are mostly games with ideal situations. Scaffolds such as assistance of teachers and incorporating external means such as educational games develop learners' zones of proximal development (ZPD). Vygotsky defined ZPD as the difference between a child's actual and potential levels of development comparing to what a child can do alone and with the assistance of an expert or another agent. Play creates a zone of proximal development in the child (Berk, 1994). Addition of goal and mechanics allows children to interact with the world, people, and things which would lead to the acquisition of knowledge.

Jerome Bruner (1915), another theorist, also tackled students' interaction with the world by exploring and manipulating objects and performing experiments. As a result, students have a greater degree of remembering concepts and knowledge discovered on their own. Bruner (1978) strongly believed that games are relevant "aids" in a child's acquisition of knowledge. It can be considered as one of the "teachable moments" which an adult tutor can enter into the situation and provide a "scaffold" for the child's activities as well as a model of relevant rules. Moreover, active participation of students in the learning process marks to an intensification in intellectual potency by making acquired information more readily feasible in problem-solving, the inaction of the learning activities in terms of the intrinsic reward of discovery itself, and making the material more readily accessible in memory (J. S. Bruner, 1961).

Many authors adopted this theory of Piaget particularly to games with rules which is viewed as the highest form of play as helping with development. These include chemical elements bingo, (Tejeda & Palacios, 1995) Chemistry "game show," (Campbell & Muzyka, 2002; Grabowski & Price, 2003; Houten, 2009; Keck, 2000) and Chemistry logic puzzle (Peris, 2007). Moreover, other games are biochemistry word searches, (Helser, 2003) Sudoku puzzles, (Crute & Myers, 2007) online spectroscopy game, (Bradley et al., 2009) and puzzles utilizing named reactions in Organic Chemistry (Erdik, 2005).

Adopting the theory of Piaget, this study aims to determine the effectiveness of ChemSaga in reinforcing conceptual topics of Periodic Table of Elements with the Grade 8 students of MAIHS for School Year 2017-2018. The lessons incorporated in the game are the history of the Periodic Table of Elements, positions of elements found in the Periodic Table of Elements, and the periodic trends.

Likewise, this paper aims to determine students' level of satisfaction and acceptability in playing ChemSaga. Along the same lines, it attempts to find out whether there is a significant difference in students' academic achievement after exposure to educational board game when taken as a whole and grouped according to sex.

Materials and Methods

This study employed the experimental research design, specifically the pre-test and post-test design since the study is restricted in the usefulness of the educational board game. This design was utilized because the intervention was made in the duration of the study. An experimental research design as stated by Blakstad (2014) is a systematic approach to research in which the researcher manipulates one or more variables, and controls and measures any change in other variables. The investigation was conducted at Mansilingan Agro-Industrial High School, a school situated in Concordia Street, Mansilingan, Bacolod City, Negros Occidental. The instruction was done in the classroom of the participants. The subjects of the study are the 44 students consisting of 14 males, and 30 females of Grade 8-Amethyst of MAIHS enrolled for the academic year 2017 – 2018.

In determining the students' level of satisfaction and acceptability, the researcher used the survey adapted from Guerra (2015).

This survey consists of thirteen items: the eight items address the level of satisfaction, and the five items address the level of acceptability. It is a five-point Likert scale from *unsatisfactory* (one) to *satisfactory* (five). Since the 13-item survey was adapted and standardized, the validation process was not utilized.

In the students' pre-test and post-test, the researcher constructed a teacher-made test. The teacher-made test covered topics about the Periodic Table of Elements. The researcher based his test questions on the created table of specifications. The said test was a multiple-choice type which is composed of forty items. The instrument used to determine academic achievement was validated by the jury of experts in the field of Science. Validation of the instrument using Good and Scates resulted in a value of 4.8 which was interpreted as Very Good while Content Validity Ratio (CVR) found that all items were essential.

For the instrument to be considered reliable, it should generate consistent and constant results (Sauro, 2015). To establish the reliability of the instrument, the researcher administered the questionnaire to 44 Grade 8 students of Bacolod City National High School (BCNHS) Alijis Extension. The 44 students pilot-tested the instrument and were not included as participants in the study. The researcher used Kuder and Richardson Formula 20 Test to check the internal consistency of the measuring instrument. Reliability of the teacher-made test is confirmed by the total value of the coefficient of correlation (r) = 0.70 which interpreted as reliable.

The data-gathering was initiated after the questionnaire passed the validity and reliability tests and was done in three stages: (1) the pre-experimental stage, (2) the experimental stage, and (3) the post-experimental stage.

Pre-experimental Stage

The researcher secured a permit to conduct the study from the principal of MAIHS. The researcher designed and made the prototype of an educational board game with its corresponding rules and mechanics. A pre-test on the lessons in the Periodic Table of Elements was given to students before the start of the experiment. The action provides the researcher baseline data in comparing students' academic achievement before and after the students were exposed to an educational board game.

Experimental Stage

The researcher noted the classroom atmosphere of the subjects, its lightings and ventilation, and the utilization of the sixty-minute class period. Overall, the classroom was well-lit and conducive to learning. The lessons about the Periodic Table of Elements were discussed, and the subjects were exposed to the educational game to review their discussion in the Periodic Table of Elements.

Educational Board Game Rules and Mechanics

The educational game "ChemSaga" is based on a mixture of question and answer type and luck board game, where player's tokens are moved based on every correct answer that they are responding. The game is composed of a board game (Figure 1), three (3) tokens, one (1) die, and list of questions. The game requires a minimum of two (2) to three (3) players. This game can also be played simultaneously in groups. The game mechanics and goals were chosen for the learners to easily understand and get into the game since it is similar to the "Snakes and Ladders" board game. The game runs from 10 to 15 minutes enough to suit in an hour duration of classes. This game can also be repeated which can aid retention of concept in the part of the students and can also help them to reinforce conceptual topics of Periodic Table of Elements.

To play the game, the players initially position their tokens on the square labeled

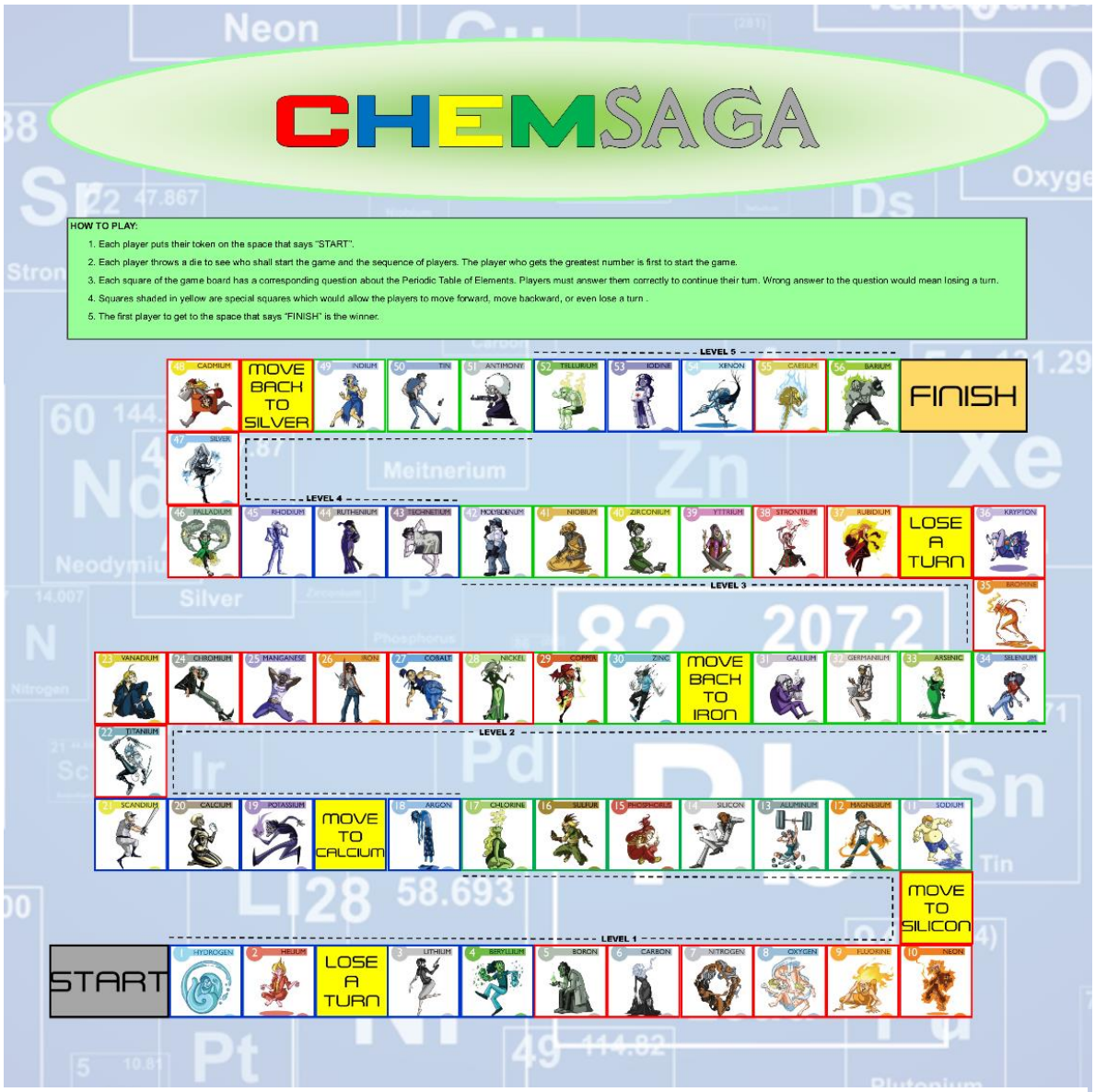

Figure 1. The board that was used in the game "ChemSaga."

"Start" (see Figure 2). First, each player throws the dice to see who start the game and the sequence of players. After that, the player rolls the dice and advances the number of squares indicated on it. Each square of the game board is labeled with an element and its corresponding atomic number. Each square has a corresponding question to be asked to the player once their token landed on it and is also bordered with colors which would indicate the category of the question. Blue-colored squares are for the History of the Periodic Table, Red-colored squares are for Positions of the Elements in the Periodic Table of Elements, and Green-colored squares are for the Trends in the Periodic Table of Elements. If the player got the correct answer to the specific question, the player would continue to roll the dice and play its turn. A player will lose a turn once he or she failed to give the correct answer to the question of the game master or his or her token landed on special squares. Squares shaded in yellow are special squares which would allow the player to move forward, move backward, or even lose a turn. The difficulty of the game increases as players continue the game. The first one to reach or exceeds the square labeled "Finish" will be the winner.

Post-experimental Stage

At the end of the game, the students' level of satisfaction and acceptability to ChemSaga as an educational tool were determined using a survey containing 13 items (Table 1). A 5-point Likert-type scale was used from *unsatisfactory* (one) to *satisfactory* (five). Table 1 presents the thirteen items that were used in the survey and its respective subjects and statements for a response.

Table 1. Thirteen items that were used in the survey.

Item	Subject	Statements or responses
	Level of Satisfaction	
1	Concentration	The game demands concentration.
2	Challenge	The game is challenging.
3	Ability	The game demands or develops some abilities.
4	Goal	The goal of the game is obvious.
5	Rules	The rules of the game are understandable.
6	Presentation	The presentation of the game is appropriate.
7	Socialization	The game enables socialization.
8	Satisfaction	I recommend the game to other classes.
	Level of Acceptability	
9	Approaching	The game proper approaches the periodic table of elements.
10	Goal	The educational goals of the game are obvious.
11	Motivation	The game is motivating.
12	Application	The game is applicable to other chemical concepts.
13	Adaptation	The discussed content is appropriate to my skills.

Moreover, post-test on the lessons in the Periodic Table of Elements was also given to the subjects to determine their mean gain academic achievement after their exposure to the educational board game. In answering Problem No. 1 and No. 2, on the students' level of satisfaction and acceptability about ChemSaga as an educational board game, the learners were given a 5-point Likert-type scale for them to evaluate the board game. After which, the researcher generated a result by utilizing mean and standard deviation with its corresponding interpretation.

In answering Problem No. 3 and No. 4, the mean and standard deviation were used to determine the result of students' academic achievement before and after exposure to educational board game when taken as a whole and grouped according to sex. The mean and standard deviation of the pre-test, posttest 1, and posttest two were compared to see the mean gain academic achievement of the students. In interpreting the students' academic achievement before and after exposure to the educational board game, Table 2 was used.

Table 2. Score and description in interpreting the students' academic achievement before and after exposure to educational board game.

SCORE	DESCRIPTION
36 – 40	Outstanding
26 – 35	Very Satisfactory
16 – 25	Satisfactory
6 – 15	Fairly Satisfactory
0 – 5	Did Not Meet Expectations

As to the significant difference in the students' mean gain academic achievement after exposure to educational board game when grouped according to sex, Mann

Whitney U and Kruskall Wallis were employed, respectively.

Results and Discussion

The result and discussion of data are as a result of this discussed and shown in tabular form according to the sequence of the statement of the problem and hypotheses which were presented in Chapter 1.

Table 3. *Students' Level of Satisfaction of ChemSaga.*

Variables	Cat	M	SD	Int
Sex	Male	4.74	0.47	Very Satisfied
	Female	4.85	0.36	Very Satisfied
As a Whole		4.59	0.68	Very Satisfied

4.51 – 5.00	Very Satisfied
3.51 – 4.50	Satisfied
2.51 – 3.50	Neither
1.51 – 2.50	Dissatisfied
1.00 – 1.50	Very Dissatisfied

The data presented in Table 3 reveals that students were delighted in playing ChemSaga as an educational game. The students understood the goal, rules, and presentation of the game.

Hromek and Roffey (2009) stated that games are fun for children and young people and therefore highly motivating. They provide the potential for transformative learning through cooperation, social interaction, social connectedness, and collaboration, and possess many of the features that encourage student well-being and resilience. In this situation, the students were given a goal which can be achieved by answering each item correctly. Moreover, the game allows the children to collaborate with their peers who had given them enticement to finish the game first. Learning takes place alongside social interaction and collaboration. The goal and the challenges they encounter in the board game stimulated their interest, and it continues to increase every time students surpassed each level of the game.

Harrington and Oliver (2012) also added that games provide information in a relevant context or setting. By making use of the educational game to reinforce concepts, it had given the learners information differently in such a way that they acquire knowledge not similar to the usual mode that teachers provide during class discussion. Through the use of an educational game, learner unlocks another gateway to store information and allows them to progress individually. In the study of Daubenfeld and Zenker (2015), making use of educational games increase student motivation, enthusiasm, and academic achievement. Also, Vos, Van Der Meijden, and Denessen (2011) justified that games have the potential to enhance motivation for learning because they stimulate curiosity and interest by presenting learning activities in meaningful contexts in which the learner is in control thus provide a higher level of intrinsic motivation. Antonio Joaquin; Franco-Mariscal, Olivia-Martinez, and Gil (2015) also concluded that educational games could be considered as powerful tools in science and, when used appropriately, they are an excellent resource for the teaching and learning process.

Table 4. Students' Level of Acceptability of ChemSaga.

Variables	Categories	M	SD	Interpretation
Sex	Male	4.85	0.36	Very Good
	Female	4.70	0.50	Very Good
As a Whole		4.74	0.47	Very Good

4.51 – 5.00 Very Good 3.51 – 4.50 Good
2.51 – 3.50 Acceptable 1.51 – 2.50 Poor
1.00 – 1.50 Very Poor

The data presented in Table 4 shows that the mean score of students' level of acceptability in playing ChemSaga was 4.74 and was interpreted as Very Good. The approach, goal, motivation, application, and adaptation of the game are clear and well-defined.

Charsky and Ressler (2011) noted that although games can be active learning environments, not all games are valid, nor are all games educational. Similarly, not all games are acceptable for all learners or all learning outcomes. In this situation, the level of acceptability of students towards the competition is high since the level of satisfaction that they have experienced was also high. The value of the game is much appreciated by the learners if they find the game challenging and goal-oriented. Games may remain on the sidelines until rubrics and evaluation strategies are developed that assess a game's value (Oblinger, 2006). However, Prensky (2001) stated that for an educational game to become active, the educational game design must achieve a balance between fun and educational value. Games have rules that give us structure. They have goals that motivate us. They are interactive that provides us with doing. They are adaptive that offers us with the flow. They have outcomes and feedback that gives us learning. They have an interaction that provides us, social groups. Antonio Joaquin; Franco-Mariscal, Olivia-Martinez, and Gil (2015) affirmed that games could be considered as a valuable instrument to overcome the conceptual difficulties particularly in correcting misconceptions of the student. By making use of games, the challenge of students in a specific area or topic can be altered and may also lead the students to face their difficulty because students have unlocked other ways on how to learn the subject. Also, they stated that students' perceptions of the experimental group using educational games were more positive than pupils' perceptions when using classroom tasks in the control group. It implies that adaptability and appropriateness of the game to students are vital to the game's educational value. Foster (2008) also added that games could be used for learning and developing personal interest by utilizing the affordances for personal identity, applicability beyond the school setting and a personal agenda, and relevance of scientific practices and ideas.

Table 5. Students' Academic Achievement before and after Exposure to Educational Board Game when taken as a whole and when grouped according to Sex.

Variable	Categories	Before Exposure			Post Test 1			Post Test 2		
		M	Description	SD	M	Description	SD	M	Description	SD
Sex	Male	12.18	Fairly Satisfactory	2.82	22.45	Satisfactory	3.83	26.18	Very Satisfactory	3.03
	Female	12.27	Fairly Satisfactory	3.61	19.64	Satisfactory	4.05	21.73	Satisfactory	4.63
As a Whole		12.25	Fairly Satisfactory	3.40	20.34	Satisfactory	4.14	22.84	Satisfactory	4.68

36 – 40 Outstanding
26 – 35 Very Satisfactory
16 – 25 Satisfactory
6 – 15 Fairly Satisfactory
0 – 5 Did Not Meet Expectations

The data presented in Table 5 reveals that before the students were exposed to the educational board game, they obtained the mean score of 12.25 which was interpreted as Fairly Satisfactory as they acquired the standard deviation of 3.40. After the exposure to the educational board game, they obtained the mean of 24.84 with the standard deviation of 4.68 which was interpreted as Satisfactory. The result simply showed that the students' academic achievement progressed after exposure to an educational board game.

Echeverria et al. (2011) indicated that games could be beneficial to the learner as they give immediate feedback, facilitate the transfer of concepts from theory to practice, enable the players to progress at individual rates, allow them to fail gracefully and provide them with the freedom to explore and discover. Vos, Van Der Meijden, and Denessen (2011) added that by playing games, children are confronted with problems they must overcome if they want to reach their goals. Through trial-and-error, children learn from their mistakes and their efforts to find a solution to the problem. In this end, the learner acquires the concept. If ever a student committed errors, they have the luxury of not letting others know about it and try to go on, discover, and hit which results to their satisfaction, acceptability, and academic achievement. Gee (2004) stated that games are very suited to the development of inquiry skills through which children learn by making hypotheses and testing them. Amory and Seagram (2004) also confirmed that educational games that are built on sound educational theories could be seen as instruments that promote the use of modern educational approaches in the classroom.

Table 6. *Difference in the Students' Mean Gain Academic Achievement after Exposure to Educational Board Game when Grouped According to Sex*

Variable	Categories	Mean Gain	SD	*p*-value	Sig @ 0.05
Sex	Male	3.73	1.95	0.09	Not Significant
	Female	2.09	3.67		

*if $p < 0.05$ Significant

The data presented in Table 6 shows that the mean gain and standard deviation of male students are 4.00 and 1.95. The mean increase and standard deviation of female students are 2.09 and 3.67. Moreover, the p-value is 0.09 which shows that there was no significant difference in the students' academic achievement after exposure to educational board game across different sex. The result means that the educational game in teaching Periodic Table of Elements in Grade 8 students is valid regardless of their sex.

Likewise, the studies of Vogel et al. (2006) through the meta-analysis of various studies on gender, showed that there is no significant performance difference between the two genders and concluded that both genders do benefit from educational games cognitively. As to every learner imagines a situation every time they play the game, their goal is still to finish the game and win. A male student may view the game as an adventure type, and a female student may see it as puzzle type, both of them were confronted an obstacle that they need to hurdle for them to win the game. Also, Annetta, Mangrum, Holmes, Collazo, and Cheng (2009) in one of their study found no significant gender difference in science achievement in examining the effect of games on science achievement. Along the same lines, Ke and Grabowski (2007) and Papastergiou (2009) investigated the impact of games on science achievement high school students, finding no significant difference in sex. Educational games help improve the academic performance of students regardless of their sex.

Furthermore, areas in students' acceptability to a specific game such as the concentration, challenge, ability, goal, rules, presentation, and socialization affect their mean gain academic performance. Thus, the idea of targeting a student's satisfactoriness concerning a specific game should be taken into account by teachers. As long as teachers provide fun and goal-oriented game to students, it will give them a different view of learning and will fuel them to perform well in the lesson.

Conclusions

One of the ways to develop students' motivation is by incorporating games into lessons. An educational game as a way in teaching Science specifically, Periodic Table of Elements has a positive effect on the academic performance of students. Positive effect on academic performance may be due to students' interest, motivation, satisfaction, and collaboration with other students. Educational games are useful educational tools that facilitate learning enjoyably. Through incorporating educational games in the lesson, it gives the learners another perspective on how to acquire information to the topic. Challenges in the game are very vital since these challenges will confront the learners. The eager-to-win learners, once faced with challenges, keeps their mind active for them to reach their goal. The power of using games to teach concepts lies in the interactional nature of playing a game together. Students have a better grasp of knowledge once they learn by doing. Students perform and think well because they have a specific goal to reach. Their motivation was high thus yield a positive outcome on their academic achievement.

The educational board game is useful for students regardless of their sex. The result of this study disclosed that ChemSaga as educational board game was accepted by the students. The game successfully motivated students in reinforcing their background and foundations in the Periodic Table of Elements, providing enjoyable activities in the classroom and enabling the socialization of the students.

Literature Cited

American Chemical Society. (2012). ACS Guidelines and Recommendations for the Teaching of High School Chemistry.

American Chemical Society. (2015). Committee on Professional Training Development of Student Skills in a Chemistry Curriculum.

Amory, A., & Seagram, R. (2004). Educational game models: conceptualization and evaluation. *South African Journal of Higher Education*, *17*(2), 206–217. Retrieved from https://doi.org/10.4314/sajhe.v17i2.25314

Annetta, L., Mangrum, J., Holmes, S., Collazo, K., & Cheng, M.-T. (2009). Bridging Reality to Virtual Reality: Investigating gender effect and student engagement on learning through video

game play in an elementary school classroom. *International Journal of Science Education*, *31*(8), 1091–1113. Retrieved from https://doi.org/10.1080/09500690801968656

Antunes, M., Pacheco, M. A. R., & Giovanela, M. (2012). Design and Implementation of an Educational Game for Teaching Chemistry in Higher Education. *Journal of Chemical Education*, *89*(4), 517–521. Retrieved from https://doi.org/10.1021/ed2003077

Bayir, E. (2014). Developing and Playing Chemistry Games To Learn about Elements, Compounds, and the Periodic Table: Elemental Periodica, Compoundica, and Groupica. *Journal of Chemical Education*, *91*(4), 531–535. Retrieved from https://doi.org/10.1021/ed4002249

Berk, L. E. (1994). Vygotsky's theory: The importance of make-believe play, *50*(1), 30–39. Retrieved from ERIC database. (EJ493655)

Blakstad, O. (2014). Experimental Research - A Guide to Scientific Experiments. Retrieved August 12, 2017, from https://explorable.com/experimental-research

Bradley, J., Lancashire, R. J., Lang, A. S. I. D., & Williams, A. J. (2009). The Spectral Game : leveraging Open Data and crowdsourcing for education, *10*, 1–10. Retrieved from https://doi.org/10.1186/1758-2946-1-9

Bruner, J. (1915). Discovery Learning (Bruner) - Learning Theories. *Harvard Educational Review*, (37), 16–25. Retrieved from https://www.learning-theories.com/discovery-learning-bruner.html

Bruner, J. S. (1961). The Act of Discovery. *Harvard Educational Review*, (31), 21–32. Retrieved from http://psycnet.apa.org/record/1962-00777-001

Bryan, R. R., Glynn, S. M., & Kittleson, J. M. (2011). Advanced Placement Intent of High School Students Learning Science, 1049–1065. Retrieved from https://doi.org/10.1002/sce.20462

Bullock, D., College, B., Hollett, V., Lewis, G., Nation, P., Williams, M., & Walter, C. (2013). ELT Journal. *Educational Leadership*, *67*(April).

Campbell, S., & Muzyka, J. (2002). Chemistry Game Shows. *Journal of Chemical Education*, *79*(4), 458. Retrieved from https://doi.org/10.1021/ed079p458

Charsky, D., & Ressler, W. (2011). "Games are made for fun": Lessons on the effects of concept maps in the classroom use of computer games. *Computers and Education*, *56*(3), 604–615. Retrieved from https://doi.org/10.1016/j.compedu.2010.10.001

Cook, E., Kennedy, E., & McGuire, S. Y. (2013). Effect of Teaching Metacognitive Learning Strategies on Performance in General Chemistry Courses. *Journal of Chemical Education*, *90*(8), 961–967. Retrieved from https://doi.org/10.1021/ed300686h

Crute, T. D., & Myers, S. A. (2007). Sudoku Puzzles as Chemistry Learning Tools. *Journal of Chemical Education*, *84*(4), 612. Retrieved from https://doi.org/10.1021/ed084p612

Daubenfeld, T., & Zenker, D. (2015). A Game-Based Approach to an Entire Physical Chemistry Course. *Journal of Chemical Education*, *92*(2), 269–277. Retrieved from https://doi.org/10.1021/ed5001697

de Freitas, S., & Oliver, M. (2006). How can exploratory learning with games and simulations within the curriculum be most effectively evaluated? *Computers & Education*, *46*, 249–264.

Dede, C. (2005). Planning for Neomillennial Learning Styles, (1), 7–12.

Denny, R. A., Lakshmi, R., Chitra, H., & Devi, N. (2000). Elementary Who Am I Riddles. *Journal of Chemical Education*, *77*(4), 477. Retrieved from https://doi.org/10.1021/ed077p477

Echeverria, A., Garcia-Campo, C., Nussbaum, M., Gil, F., Villalta, M., Amestica, M., & Echeverria, S. (2011).

A framework for the design and integration of collaborative classroom games. *Computers and Education*, *57*(1), 1127–1136. Retrieved from https://doi.org/10.1016/j.compedu.2010.12.010

Erdik, E. (2005). Using Building-Block Puzzles To Practice Drawing Organic Mechanisms. *Journal of Chemical Education*, *82*(9), 1325. Retrieved from https://doi.org/10.1021/ed082p1325

Foster, A. (2008). Games and motivation to learn science: Personal identity, applicability, relevance and meaningfulness. *Journal of Interactive Learning Research*, *19*(4), 597–614. Retrieved from http://ezproxy.deakin.edu.au/

Franco-Mariscal, A. J., Martínez, J. M. O., & Márquez, S. B. (2012). An Educational Card Game for Learning Families of Chemical Elements. *Journal of Chemical Education*, (May 2014). Retrieved from https://doi.org/10.1021/ed200542x

Franco-Mariscal, A. J., Oliva-Martínez, J. M., & Almoraima Gil, M. L. (2014). Students' Perceptions about the Use of Educational Games as a Tool for Teaching the Periodic Table of Elements at the High School Level. *Journal of Chemical Education*, *1*(12), 146–149. Retrieved from https://doi.org/10.1021/ed4003578

Franco-Mariscal, A. J., Oliva-Martínez, J. M., & Gil, M. L. A. (2015). Students ' Perceptions about the Use of Educational Games as a Tool for Teaching the Periodic Table of Elements. Retrieved from https://doi.org/10.1021/ed4003578

Franklin, S., Peat, M., & Lewis, A. (2003). Non-traditional interventions to stimulate discussion: The use of games and puzzles. *Journal of Biological Education*, *37*, 79–84.

Gee, J. P. (2004). Learning by design: Games as learning machines. *Interactive Educational Multimedia*, *8*(8), 15–23. Retrieved from http://www.ub.es/multimedia/iem

Gilakjani, A. P., & Branch, L. (2012). Visual , Auditory , Kinaesthetic Learning Styles and Their Impacts on English Language Teaching, *Journal of Studies in Education*, *2*(1), 104–113. Retrieved from https://doi.org/10.5296/jse.v2i1.1007

Grabowski, J. J., & Price, M. L. (2003). Simple HTML Templates for Creating Science-Oriented Jeopardy! Games for Active Learning. *Journal of Chemical Education*, *80*(8), 2003.

Guerra, A. C. O. ., Pegas, M. M. ., & da Silva, J. F. M. (2015). "Organic & Action" – An Educational Game to teach Organic Chemistry. *Instituto de Quimica*, 110–115.

Helser, T. L. (2003). Terminology: Four Puzzles from One Wordsearch. *Journal of Chemical Education*, *80*(4), 414. Retrieved from https://doi.org/10.1021/ed080p414

Herrington & Oliver. (2012). Games based learning theory. *Games and Culture*, *1*(1). Retrieved from http://www.games-ed.co.uk/learning-theory.html

Houten, J. Van. (2009). "Jeopardy" in the Inorganic Classroom - Teaching Descriptive Chemistry Using a Television Game Show Format. In *Chemistry Education in the ICT Age* (pp. 11–17). Dordrecht: Springer Netherlands. Retrieved from https://doi.org/10.1007/978-1-4020-9732-4_2

Hromek, R., & Roffey, S. (2009). Promoting Social and Emotional Learning With Games: "It's Fun and We Learn Things." *Simulation & Gaming*, *40*(5), 626–644. Retrieved from https://doi.org/10.1177/1046878109333793

Ke, F., & Grabowski, B. (2007). Gameplaying for maths learning : cooperative or not ? *British Journal of Educational Technology*, *38*(2), 249–259. Retrieved from https://doi.org/10.1111/j.1467-8535.2006.00593.x

Keck, M. V. (2000). A Final Exam Review

Activity Based on the Jeopardy Format. *Journal of Chemical Education*, *77*(4), 483. Retrieved from https://doi.org/10.1021/ed077p483

Kinzie, M. (2015). Gender differences in game activity preferences of middle school children: Implications for educational game design. *Educational Technology Research and Development*, *1*(August), 1–22. Retrieved from https://doi.org/10.1007/s11423-007-9076-z

Kirriemuir, J., & Mcfarlane, A. (2007). Literature Review in Games and Learning. *Games and Culture*, *1*(1), 1–40.

Koether, M. (2003). The Name Game: Learning the Connectivity between the Concepts. *Journal of Chemical Education*, *80*(4), 421–422. Retrieved from https://doi.org/10.1021/ed080p421

Kumar, R., & Lightner, R. (2007). Games as an Interactive Classroom Technique: Perceptions of Corporate Trainers , College Instructors and Students. *International Journal of Teaching and Learning in Higher Education*, *19*(1), 53–63. Retrieved from http://isetl.org /ijtlhe/articleView.cfm?id=157

Marais, F., & Combrinck, S. (2009). An Approach to Dealing with the Difficulties Undergraduate Chemistry Students Experience with Stoichiometry. *South African Journal of Chemistry*, *62*(1), 88–96. Retrieved from https://www.ajol.info/index.php/sajc/article/view/123215

Marasigan, A. C., & Espinosa, A. A. (2014). Modified Useful-Learning Approach : Effects on Students' Critical Thinking Skills and Attitude towards Chemistry. *International Journal of Learning, Teaching and Educational Research*, *1*(1), 35–72.

Marti-Centelles, V., & Rubio-Magnieto, J. (2014). ChemMend : A Card Game To Introduce and Explore the Periodic Table while Engaging. *Journal of Chemical Education*, (April). Retrieved from https://doi.org/10.1021/ed300733w

Melero, J., & Hernández-leo, D. (2014). A Model for the Design of Puzzle-based Games Including Virtual and Physical Objects. *Educational Technology and Society*, *17*(3), 192–207.

Moreno, L. F., Hincapié, G., & Alzate, M. V. (2014). Cheminoes: A Didactic Game To Learn Chemical Relationships between Valence, Atomic Number, and Symbol. *Journal of Chemical Education*, *91*(6), 872–875. Retrieved from https://doi.org/10.1021/ed4008183

Oblinger, D. (2006). Simulations , Games , and Learning. *EDUCAUSE Review*, *1*(May), 1–6.

Papastergiou, M. (2009). Digital Game-Based Learning in High School Computer Science Education: Impact on Educational Effectiveness and Student Motivation. *Computers & Education*, *52*(1), 1–12. Retrieved from https://doi.org/10.1016/J.COMPEDU.2008.06.004

Peris, M. (2007). A Disciplined Chemical Puzzle. *Journal of Chemical Education*, *84*(4), 609. Retrieved from https://doi.org/10.1021/ed084p609

Piaget, J. (1962). *Play, dreams, and imitation in childhood*. *New York, NY: Norton*.

Piaget, J. (1964). Cognitive Development in Children: Piaget Development and Learning. *Journal of Research in Science Teaching*, *2*(3), 176–186. Retrieved from https://doi.org/10.1002/tea.3660020306

Pieroni, O. I., Vuano, B. M., & Ciolino, A. E. (2000). Classroom Innovation: Games to Make Chemistry More Interesting and Fun. *The Chemical Educator*, *5*(4), 167–170. Retrieved from https://doi.org/10.1007/s00897000393a

Prensky, M. (2001). Fun , Play and Games : What Makes Games Engaging. *Digital Game-Based Learning*, 1–31. Retrieved from https://doi.org/10.1103/PhysRevB.66.085421

Rapeepisarn, K., Wong, K. W., Fung, C. C., & Khine, M. S. (2008). The Relationship between Game Genres , Learning Techniques and Learning

Styles in Educational Computer Games. *Technologies for E- Learning and Digital Entertainment*, *5093*, 497–508.

Ratner, N., & Bruner, J. (1978). Games, social exchange and the acquisition of language. *Journal of Child Language*, *5*(3), 391–401. Retrieved from https://doi.org/10.1017/S0305000900002063

Russell, J. V. (1999). Using Games To Teach Chemistry: An Annotated Bibliography. *Journal of Chemical Education*, *76*(4), 481. Retrieved from https://doi.org/10.1021/ed076p481

Sauro, J. (2015). MeasuringU: How to Measure the Reliability of Your Methods and Metrics. Retrieved August 12, 2017, from https://measuringu.com/measure-reliability/

Sirhan, G. (2007). Learning Difficulties in Chemistry : An Overview. *Turkish Science Education*, *4*(2), 2–20.

Spandler, C. (2016). Mineral Supertrumps: A New Card Game to Assist Learning of Mineralogy. *Journal of Geoscience Education*, *64*(May), 108–114. Retrieved from https://doi.org/10.5408/15-095.1

Tanni, Z. A., & Mahmoud, A. A. A. (2012). Using Games to Promote Students ' Motivation towards Learning English. *Journal for Educational & Psychological Research & Studies*, *2*(5), 11–23.

Tejeda, S., & Palacios, J. (1995). Chemical Elements Bingo. *Journal of Chemical Education*, *72*(12), 1115. Retrieved from https://doi.org/10.1021/ed072p1115

Treagust, D. F. (2000). Sources of students ' difficulties in learning Chemistry, (January).

Vogel, D., Bowers, C. A., & Bowers, C. A. (2006). Computer Gaming and Interactive Simulations for Learning: A Meta-Analysis. *Journal of Educational Computing Research*, *34*(3), 229–243. Retrieved from https://doi.org/10.2190/FLHV-K4WA-WPVQ-H0YM

Vos, N., Van Der Meijden, H., & Denessen, E. (2011). Effects of constructing versus playing an educational game on student motivation and deep learning strategy use. *Computers and Education*, *56*(1), 127–137. Retrieved from https://doi.org/10.1016/j.compedu.2010.08.013

Vygotsky, L. (1966). Play and its role in the Mental Development of the Child. *Voprosy Psikhologii*, *3*, 1–18. Retrieved from https://www.marxists.org/archive/vygotsky/works/1933/play.htm

Williams-Pierce, C. C. (2011). Five Key Ingredients for Improving Student Motivation. *Research in Higher Education Journal*, *1*(11), 2–24.

Wilson, A. M., Samide, M. J., & Wilson, A. M. (2014). Games, Games, Games; Playing to Engage with Chemistry Concepts. *The Chemical Educator*, *19*(1), 167–170. Retrieved from https://doi.org/10.1007/s00897132552a