Efficacy of Periodic Board-Scrabble Game (PBSG) Teaching Approach on Secondary School Students' Achievement in Chemistry.

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ABSTRACT

The dynamic role of Chemistry as a discipline in the technological development of any nation demands that more thoughtful attention be given to its method of teaching and learning. This has necessitated the innovation of different teaching approaches and strategies by Chemistry educators to enhance students' achievement and sustainability of Chemistry Education. This study investigated the efficacy of the use of Periodic Board-Scrabble Game (PBSG) teaching approach developed by the researchers on students' achievement in Chemistry. Two research questions and two hypotheses guided the study. The design of the study was quasi-experimental research design, precisely the non-equivalent pre-test and post-test control group design. The population of this study was one thousand and eighty-nine (1,089) Senior Secondary School students of the penultimate class from thirty-two Senior secondary schools in Nsukka Senatorial District of Enugu State. One hundred and forty-two students from two co-educational schools in this population were sampled purposively. Two intact classes were randomly drawn from each of the two schools. The instrument used was the Periodic Board-Scrabble Game and Chemistry Achievement Test (CAT), developed by the researchers. The reliability of the Chemistry achievement test was established using Kuder-Richardson formula 20 (K-R 20), and the index obtained was 0.94. Mean and standard deviation (SD) were used to answer the research questions while the Analysis of Covariance (ANCOVA) was used to test the null hypotheses at $p<0$ .05. The study revealed that the use of Periodic Board-Scrabble Game (PBSG) approach enhanced students' achievement in Chemistry. It was recommended that chemistry teachers should adopt the use of Periodic Board-Scrabble Game(PBS) approach in teaching the concept of the periodic table. It is also recommended that this game should be translated into a video game.

Keywords: Gamification, Periodic Board-Scrabble Game (PBSG), Achievement in Chemistry, Teaching Chemistry

INTRODUCTION

The dynamic role of Chemistry as a discipline in the technological development of any nation demands that a more thoughtful attention be given to its method of teaching and learning to ensure that effective teaching and learning takes place. Effective teaching is that teaching processes and behavior that results in useful learning outcomes, retention of learned materials and transfer of learned skills to everyday life. The purported abstractness of Chemistry concepts makes the teaching and learning difficult and continually keeps students away from Chemistry and chemistry related disciplines. It becomes imperative that for students to be interested in learning Chemistry concepts, retain and apply the learned knowledge and also go into studying Chemistry related courses in the universities, Chemistry teaching must be made interesting and effective by adopting strategies and approaches that are likely to be motivating and engaging. The students' general under achievement in Chemistry public examinations in Nigeria, such as; West African School Certificate Examination (WASE), National Examination Council Examinations (NECO), and

National Board for Technical Examinations Board (NABTEB) and Joint Admissions and Matriculation Board (JAMB) Examinations as reported by Abdi -rim, (2015); Igwe,(2015);WAEC Chief Examiner, (2017– 2022) is indicative of the fact that there is a gap to be filled in Chemistry teaching and learning process at the Secondary School level in order that this unimpressive situation be amended. Excellent academic achievement of students in Chemistry at this level is a key factor for any nation that craves for technological development because it is a very important display of knowledge and skill acquisition. The situation demands the immediate intervention of Chemistry educators in many areas including the development of new teaching strategies and approaches for teaching Chemistry that are different from the conventional approaches and strategies.

Chemistry is highly conceptual subject with high abstract of ideas that requires high cognitive thinking to meaningfully grasp and understand its concept (Taber, 2019), thus its teaching demands particular attention for proper development of scientific habits in student which can be transferred to other areas of life for national development. Chemistry is the key to national development as it impacts our day-to-day life activities, in the area of Industrial applications, Medicine, Agriculture, Engineering and Economy. In simple terms the products that directly affect our daily lives, what we eat, our health, what we wear, our transport, the technology we use in our homes, at school and everywhere including electricity are all dependent on Chemistry and Chemical industries. This simply implies that, the development of any nation is driven by a functional chemistry education and so, Chemistry must be taught well at all levels of education. Hence, the need to help students of all genders understand the Chemistry concepts in its simplest forms, then see the relationship between Chemistry and life and experience science in practical terms. Consequently, this will awaken their environmental consciousness and open their mind to acquire the required knowledge and scientific skills that will be applied in the national development. Gender is an important variable in this study because of the conflicting reports on students' achievement in Chemistry with respect to gender, with a number of scholars reporting male students outperforming the female students in Chemistry and Physics. An innovative approach that could capture the interest of both male and female students could be of great help in changing the tide in achievement through universal impartation of knowledge and skills.

A notable way of imparting Chemistry knowledge and skills for transfer and innovation is by making the concepts appear concrete rather than abstract. One approach of making the concepts concrete and real to the students is through the use of game teaching approach otherwise called gamification(Alex,2018). A game is a competitive activity involving two or more persons who plays according to a set of rules usually for their own amusement or for that of spectators. Gamification of learning is an educational approach to arouse students' interest to learn by using game design in teaching. Gamification enhances the level of engagement thus improves the students' acquisition of a particular skill. This is expected to create pleasant environment for learning to take place. An instructional game is a structured activity with set of rules for playing in which two or more students interact to reach a clearly designated instructional objective (Orim & Ekwueme,2001). This can be done manually or as a video game. The goal is to generate a level of involvement and interest on the part of the students of all genders, create the consciousness and reality of the

contents they are studying, make retention of knowledge possible and hence improve achievement.

It is therefore the aim of this study to use the Periodic Board -Scrabble Game(PBSG) as an approach to teach the Periodic table at the Secondary Schools with an aim to advancing achievements. Periodic table is a chemistry content that houses the building blocks of all the chemical elements in existence. Its proper understanding makes way for the understanding of chemical reactions and properties of every element and compound that exist in nature. This fundamental concept in Chemistry, when not properly understood, makes the understanding of further concepts in Chemistry become difficult and tasking to the learners, and the achievement of the objectives of Chemistry education becomes a mirage. A number of Chemistry game approaches have been advocated in literature such as; Chemcaper, Holo LAB Champions, Organic Pop,

Happy Atomsamong others, but none of them captured the periodic table in its entirety. This study is therefore poised to use a periodic table game called Periodic Board-Scrabble Game (PBSG) developed and coined by the researchers to teach the concept of the periodic table.

Purpose of the study

Improvement on students' achievement on examinations depends largely on the method of content presentation and on the students. The teacher is expected to put in place some strategies and activities that would arouse and sustain the interest of students. The conventional or traditional method of teaching chemistry through listening, looking, demonstration and other similar methods seem to have resulted in making students lose interest in chemistry. It is important that any method that can arouse the students' interest and make them glued to their seats be brought into consideration. Such a method is expected not only to arouse interest but also to improve the student's retention of the chemistry concept and improve achievement both in internal and external examination. The research anchors largely on Jerome Brunner's Social Constructivism which emphasizes the importance of the active involvement of the learner in constructing knowledge for themselves and building new ideas or concept based upon current knowledge and past experience. It is against this background that this research study was conceived. Thus, the purpose of study is to determine the efficacy of Periodic Board-Scrabble Game (PBSG) in teaching the concepts of the periodic table. Specifically, the study seeks to determine:

1. The mean achievement scores of chemistry students taught periodic table using Periodic Board-Scrabble Game (PBSG) approach and those taught using conventional method.
2. The mean achievement score of male and female students in chemistry when taught periodic table using Periodic Board-Scrabble Game (PBSG) approach and those taught using conventional method.

Research Questions

1. What are the mean achievement scores of chemistry students taught the periodic table using the Periodic Board-Scrabble Game (PBSG) approach and those taught using the conventional method?
2. What is the mean achievement score of male and female students in chemistry when taught the Periodic table using the Periodic Board-Scrabble Game (PBSG) approach and those taught using the conventional method?

Hypotheses

1. There is no significant difference in the mean achievement scores of chemistry students taught the periodic table using the Periodic Board-Scrabble (PBS) game approach and those taught using the conventional method.
2. There is no significant difference in the mean achievement score of male and female students in chemistry when taught the periodic table using the Periodic Board-Scrabble (PBS) game approach and those taught using the conventional method.

METHODS

The study adopted a quasi-experimental research design. Specifically, the pretest-posttest design was adopted in the study. The population of this study was one thousand and eighty-nine (1,089) Senior Secondary School students from thirty-two secondary schools in Nsukka Senatorial District of Enugu State. One hundred and forty-two students from two co-educational schools were sampled purposively. Two intact classes were randomly drawn from each of the two schools. In each school, one class served as the experiment group and the other served as the control group. The instrument used was the Periodic Board-Scrabble Game and Chemistry Achievement Test (CAT), developed by the researchers using a test blue

print. The reliability of the Chemistry achievement test was established using Kuder-Richardson formula 20 (K-R 20), the index obtained was 0.94. This instrument was administered to both the experimental groups (the students thought with the Periodic Board-Scrabble Game) and the control groups (the students thought with the normal and conventional way of teaching chemistry), before and after the treatment. Their scores were collated and used for the analysis. Mean and standard deviation (SD) were used to answer the research questions while the Analysis of Covariance (ANCOVA) was used to test the null hypotheses at p<0 .05.

The Instrument and Procedure

The researchers developed one game in the periodic table, called Periodic Board-Scrabble (PBS) game using a board and scrabbles. A game board of about 60cm by 35cm plywood board, the board houses the elements in the periodic table, the game board was colored with different distinctive colors: Alkali Metals- Yellow, Alkaline Earth Metals-Orange, Transition Metals-Blue, Post Transition Metals-Purple, Lanthanides-Violet, Actinides-Red, Metalloids-Green, Polyatomic Non Metals-Leafy green, Diatomic Non Metals-light blue(cyan), Noble Gasses-Navy Blue. The atomic number of the elements are clearly written on the spaces. Scrabbles with symbols of the elements and their electronic configuration were provided for playing the game. Figure 1 is the comprehensive Periodic table of elements; Figure 2 is the Periodic game-scrabble beads while Figure 3 is the periodic table constructed for the game. To use this game, the teacher is expected to construct the game on a ply-wood or on a plastic sheet.

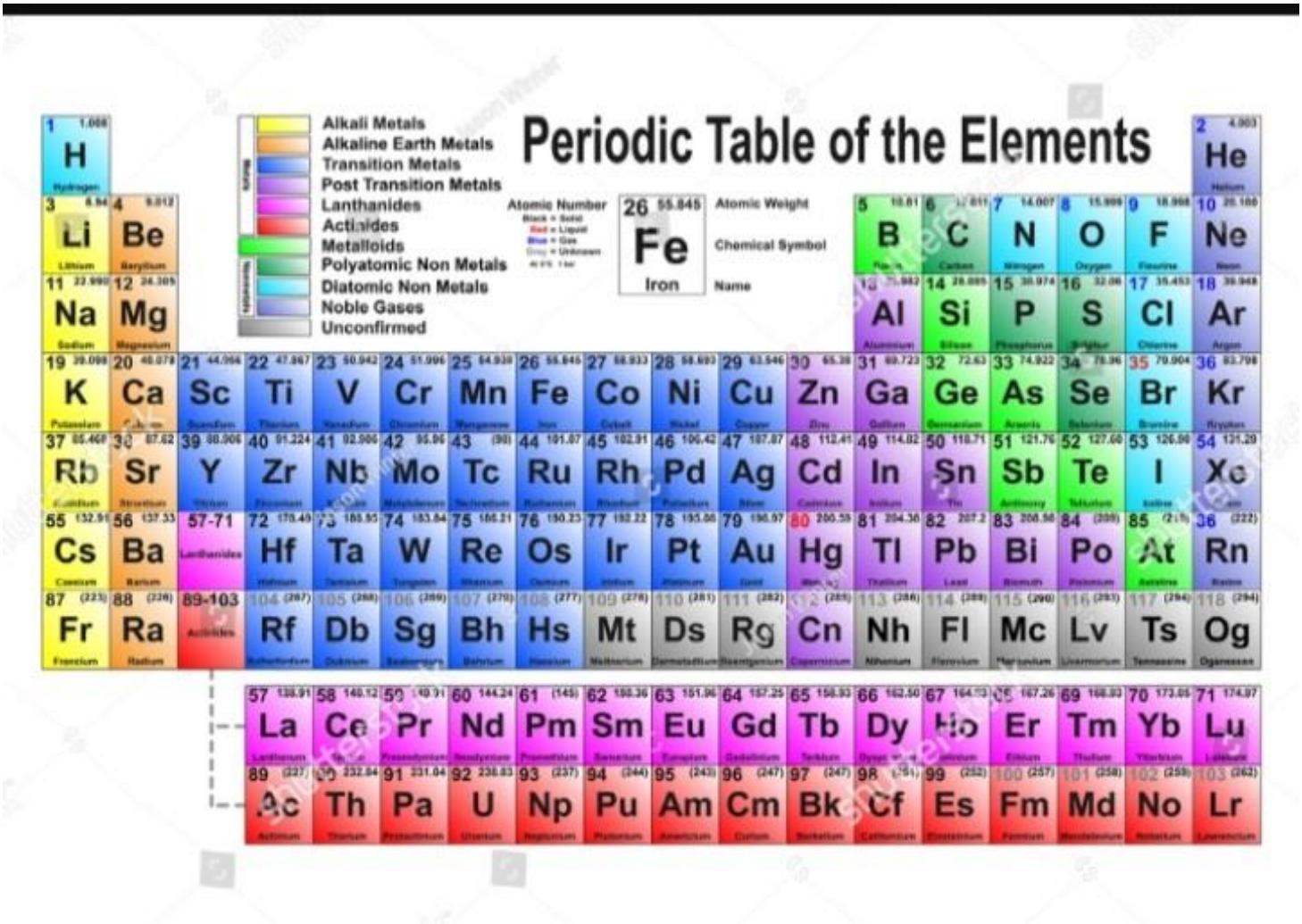

FIGURE 1

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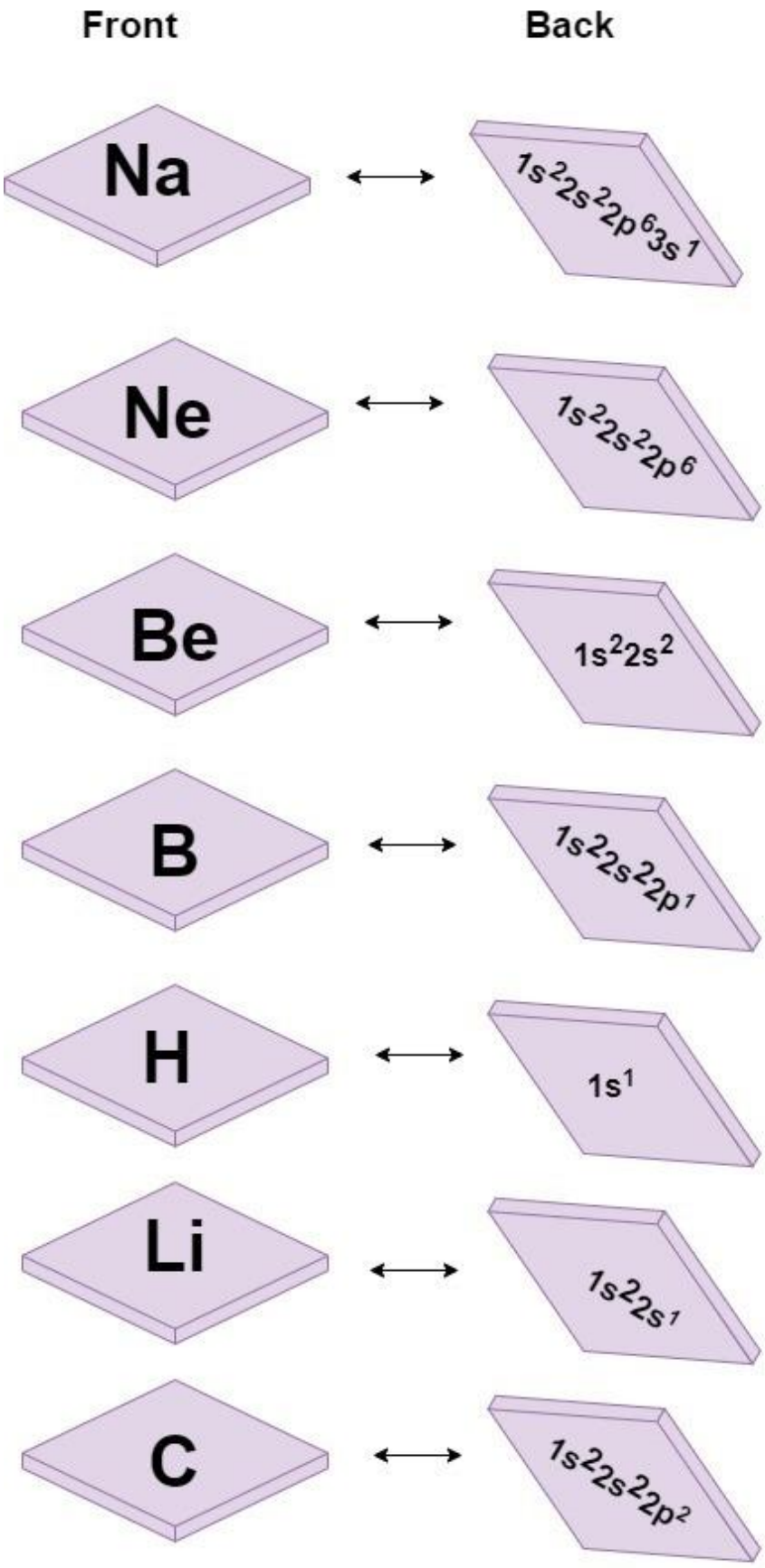

Figure 2: THE PERIODIC GAME SCRABBLE

FIGURE 3: THE PERIODIC GAME BOARD

The game can be played by 1 to 3 players. The teacher guides and coordinates the students and makes sure they don't deviate from the rules of game. One of the players shuffles the scrabble and calls a name of an element, one of the players searches for the scrabble with corresponding name of the element and matches it with the element on the game board accordingly to match with the correct electronic configuration. The game continues with each players taking turn in calling the name of the element. The players take note of the colors on the game board and uses them to group the elements as metal, non-metal or metalloid as the players look at the board, making them to internalize and memorize the names of the elements and their electronic configuration as seen in the periodic table. The winner at each instance is the first player to see the scrabble bearing the name of the element mentioned. The board have the name of the element and the electronic configuration in the format 1s, 2s 2p, …n written on it. The configurations help the players to place the elements in their respective groups using the number of outermost electron, example; the configuration of Sodium(Na) is $1s^2$, $2s^2$ $2p^6$, $3s^1$. Sodium(Na) having an outermost electron of 1 places Sodium in group 1 of the periodic table. The player fixes the element with the same outer electron in same group and those with same number of shells in the same period, the players take turn in calling the name of the element and the first person to find and match it on the board becomes the winner in each instance. The experimental group was taught the periodic table using this game, while the control group was taught the periodic table using the normal and old conventional method of teaching Chemistry concepts. The conventional method of teaching is the old approach to teaching Chemistry which involves a one-way channel of communication of information where students are not actively involved in the teaching – learning process. In the conventional approach, the students only listen and pen down some notes where necessary. During this experiment each group was given a pretest before the treatment and a posttest after the treatment. Their scores were collated and used for the analysis. This game is expected to enable the students practice and solve problems on metals, transition metals, metalloids, non-metals, and the families of elements in the periodic table according to periods and groups.

RESULTS

Table 1: Mean and standard deviation of achievement scores of students taught chemistry using the Periodic Board-Scrabble (PBS) game and those taught using conventional method

		Pre-test		Post-test		
Teaching Method	**N**	**$\bar{x}$**	**SD**	**$\bar{x}$**	**SD**	**Mean Gain.**
PBS Method	63	13.84	3.21	22.70	4.35	8.86
Conventional Method	79	13.39	3.28	18.34	2.85	4.95

Table 1 shows that students who were taught Chemistry using the Periodic Board-Scrabble Game (PBSG) had pre-test mean achievement score of 13.84 with standard deviation of 3.21 while the control group (those taught using conventional method) had pre-test mean achievement score of 13.39 with standard deviation score of 3.28. The experimental group (those taught using gamification) had a post-test mean achievement score of 22.70 with standard deviation of 4.35. Those taught using conventional method had a post-test mean achievement score of 18.34 with standard deviation of 2.85. The mean gain scores for the group taught using the Periodic Board-Scrabble (PBS) game was 8.86 against the mean gain of 4.95 recorded by the conventional method group.

Table 2: ANCOVA showing Significant Difference in the Mean Achievement Score of Students taught Chemistry using the Periodic Board-Scrabble (PBS) game and those taught using Conventional Method

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	672.807a	4	168.20	12.82	0.00	0.27
Intercept	2825.52	1	2825.52	215.36	0.00	0.61
Pre-test	6.82	1	6.82	0.52	0.47	0.00
Instructional-Approach	592.77	1	592.77	45.18	0.00	0.25
Gender	0.02	1	0.02	0.00	0.97	0.00
Instructional-Approach * Gender	0.81	1	0.81	0.06	0.81	0.00
Error	1797.48	137	13.12			
Total	60841.00	142				
Corrected Total	2470.29	141				
a R Squared = .272 (Adjusted R Squared = .251)						

Table 2 shows F-ratio of 45.18 with associated probability (Sig.) of 0.00 and effect size of 0.25 under Instructional Approach. The associated probability level is less than the 0.05 level of significance stated for testing of the null hypothesis. Therefore, the null hypothesis is rejected, which implies that there is a significant difference in the mean achievement scores of students taught Chemistry using the Periodic Board-Scrabble game and those taught using conventional method, in favor of the group taught using the Periodic Board-Scrabble Game The significant difference is evident in the moderate effect size of 0.25.

Table 3: Mean and Standard deviation of achievement scores of male and female students in chemistry taught using Periodic Board-Scrabble Game (PBSG) approach.

		Pre-test		Post-test		
Gender	**N**	**$\bar{x}$**	**SD**	**$\bar{x}$**	**SD**	**Mean Gain.**
Male	80	13.45	3.41	20.65	4.54	7.20
Female	62	13.77	3.05	19.79	3.65	6.02

Table 3 shows that the male students taught Chemistry using the Periodic Board-Scrabble Game (PBSG) approach had pre-test mean and standard deviation of achievement scores of 13.45 and 3.41 respectively while the pre-test mean and standard deviation of achievement scores for female students were 13.77 and respectively. The post-test means and standard deviation of achievement scores for the male students were 20.65 and 4.54 while post-test mean and standard deviation of achievement scores for the female students were 19.79 and 3.65 respectively. The mean achievement scores gain of 7.20 and 6.02 male and female students respectively revealed that male students slightly outperformed their female counterparts in this game.

Table 2 above also shows F-ratio of 0.00 with associated probability (Sig.) of 0.97 and effect size of 0.00 under Gender. The associated probability level is greater than the 0.05 level of significance stated for testing the null hypothesis. Therefore, the null hypothesis is not rejected, which implies that there is no significant difference in the mean achievement scores of male and female students in this game. In other words, the influence of gender is not significant in this game thus not significant on students' achievement in Chemistry.

DISCUSSION

The major findings of this research is that, there is significant effect of the use of Periodic Board-Scrabble Game (PBSG) on students' academic achievement in Chemistry. Hence the observation that he students taught the periodic table concepts using the Periodic Board-Scrabble Game (PBSG) had a higher mean gain than those students taught with the conventional method of teaching. The improved achievement of the experimental group over the control group is in agreement with a number of research findings on the influence of game method on learning, one of which is, Agwagah (2001), who stated that games encourage creative thinking in students, stir their senses, stimulate inquisitiveness and promote understanding of the concept. The main goals of gamification according to Rodrigo, et al, (2020) is to enhance certain abilities, introduce objectives that give learning a purpose, engage students, optimize learning, support behavior change, and socialize the learners. Also, Achmad, et al, (2022) affirms that gamification motivates the students to continue playing and learning. Given that chemistry is a subject full of abstract concepts and it is a central science subject that unifies all the other sciences, proper understanding of Chemistry concepts should be a priority to Chemistry educators. Consequently, learning and achievement will be optimized. The outcome of this study using PBS Game approach, has proved its effectiveness in the teaching and learning of Chemistry as evidenced in the mean scores of the experimental group of the students in the periodic table achievement tests.

CONCLUSION

In conclusion, it is clear that the game helped students both male and female to achieve higher in the achievement tests and reduced the level of abstraction involved in the chemistry concept. It captured the students' interest, provided them the opportunity to participate actively and made room for competitiveness during the teaching session. It made the students to see the connections between the concept and reality, and the students were able to recall what they learned because their abstract experiences were transformed into concrete ones. Games can therefore be applied in chemistry teaching either as a part of the lesson or during are view session. That means, games can be used as an introduction to the new material or as a platform to

revise the material and practice skills that have been previously taught since it proved very effective in the teaching, learning and understanding of the concepts in the periodic table.

RECOMMENDATION

Based on the findings of this study that the students taught Chemistry with the Periodic Board-Scrabble Game approach out performed those taught with the conventional method, the researchers recommend that gamification such as Periodic Board-Scrabble Game (PBSG) should be encouraged and used in teaching the periodic table and that as many concepts as possible in Chemistry at the secondary level of education should be taught using game approach. The researchers also recommend that the Periodic Board-Scrabble Game (PBSG) approach should be translated to a video game. A model of this game can also be built and sold commercially or distributed to schools and colleges.

REFERENCES

1. Abdel rim, H. (2015). Students' interest in science and technology and its relationships with teaching methods, family context and self-efficacy. *International journal of environmental and science education, 10*(3), 337-366. https://www.google,com/url?q=https://files.eric.ed.gov
2. Achmad, L. Fitria, A. and Bintari, E.P.(2022) Gamification: Game as a medium for learning Chemistry to motivate and increase retention of students' learning outcomes. *Journal of technical and science education.* 13(1)https://doi.org/10.3926/jotse.1842.
3. Adigwe, J.C. (2014). Effect of mathematics reasoning skills on students' achievement in Chemical Stoichiometry. *Educational Journal of University of Nigeria*, **23**(2): 1-22.
4. Agwagah, U. (2001). Mathematics Games for Primary. *The Mathematics Teacher*, **71**(2): 117-118.
5. Alex, M.O. (2018) Gamification as a concreate strategy for teaching in a vocational education setting. *International journal for Innovative education and research.*6(6) 76-86 Doi:10.31686/ijier.6(6).1061.
6. Alsawaier, R. S. (2018). The effect of gamification on motivation and engagement. *The International Journal of Information and Learning Technology*.35(1) pp56-79.https://doi.org/10.1108/IJILT-02-2017-0009.
7. Bayat, S., Kılıçarslan, H., and Şentürk, Ş. (2014). Investigating the effect of educational games in science and technology course on the academic success of students at grade 7. *AbantİzzetBaysal University Faculty of Education Journal*, **14**(2): 204-216.
8. Boot W, Kramer A., Simons D., Fabiani M., Gratton G. (2008). The effects of video game playing on attention, memory, and executive control. *Acta Psychologica.*129(3)pp 387-398.https:// doi.org/ 10.1016/ j.actpsy .2008 .09 .005
9. Delmang, T., and Gongdeng, E. (2016). Ameliorating Sudent's Performance and Attitude towards Chemistry through Chemistry Problem-Solving Techniques (CPST). *International Journal of Scientific Research in Education*, **9**(2): 41-47.
10. Igwe, I. O. (2015). Secondary Education Chemistry Curriculum Implementation in Nigeria: Contending Issues and Innovative Approaches for the future. *International Journal of Life and Applied Sciences (IJSAR-JLAS), 3*(1), 24-33. *mdcjournals.org*
11. Nwosu, A.A. (2015) Science education for life in a dynamic world. An inaugural lecture of the University of Nigeria, Nsukka.October,29,2015.
12. Okwuduba, E. N., and Okigbo, E. C. (2018). Effect of teaching methods on students' academic performance in chemistry in Nigeria: meta-analytic review. *Bulgarian Journal of Science and Education Policy*, **12**(2): 418-434.
13. Orim,R. E. and Ekwueme, C.O.,(2001) The roles of games in teaching and learning of mathematics in Junior Secondary Schools. *Global Journal of Educational research.* 10(2)globaljournalseries.com (Revise .2011)
14. Rodrigo, S. Sandro, J. R. and Patricia, A.J. (2020) The impact of gamification on students' learning,

engagement and behavior based on their personality. *Springeropen ,com* http://feeper.unisinos.br/

15. Schank, P., and Kozma, R. (2002). Learning chemistry through the use of a representation-based knowledge building environment. *Journal of Computers in Mathematics and Science Teaching*, **21**(3): 253-279.
16. Stringfield, T. W., and Kramer, E. F. (2014). Benefits of a game-based review module in chemistry courses for no majors. *Journal of Chemical Education*, **91**(1): 56-58
17. Türkmen, G. P., and Soybaş, D. (2019). The effect of gamification method on students' achievements and attitudes towards mathematics. *Barton University Journal of Faculty of Education*, **8**(1): 258-298.
18. Wu, H. K., Krajcik, J. S., and Soloway, E. (2001). Promoting understanding of chemical representations: Students' use of a visualization tool in the classroom. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, **38**(7): 821-842.