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The impact of puzzle game and video-based puzzle strategies on students' achievement and retention in periodicity

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ABSTRACT

Periodicity in chemistry is often regarded as a challenging or difficult subject owing to its seemingly abstractness and factors such as ineffective pedagogies, leading to poor achievement and low retention of knowledge. Also, the knowledge of periodicity is fundamental to students' understanding of a substantial range of chemistry concepts. Therefore, there is a need for the adoption of activity-oriented teaching methods, which have the capacity to not only foster achievement, but also encourage retention. Therefore, this study determined the effects of puzzle game and video-based puzzle strategies on secondary school students' achievement and retention in periodicity concept in chemistry. Pre-/post-test, delayed post-test control group quasi experimental research design was adopted in the study. Multi-stage sampling procedure was used in the sampling of participants. A total of 183 senior secondary school chemistry students were drawn from six purposively selected public secondary schools in Irewole Local Government Area of Osun State, Nigeria. Two categories of research instruments (stimulus and response) were developed, validated and used to collect data, which were analyzed using analysis of covariance and Bonferroni's post-hoc test. The findings of the study revealed improved achievement and retention among students exposed to experimental groups (puzzle game and video-based puzzle) than the control group (conventional teaching). Puzzle game appeared to be the most efficacious. It was therefore suggested that teachers should adopt activity-based learning approaches such as puzzle games for teaching periodicity and other chemistry concepts as an attempt to reduce the abstractness perceived by learners and consequently enhance learning outcomes including retention.

Keywords: puzzle game, video-based puzzle, gamification, achievement, knowledge retention, periodicity

INTRODUCTION

As a chemistry concept, periodicity denotes the repetition in the trends of the properties of chemical elements. Helmenstine (2020) established that periodicity provides framework for the organization of the modern periodic table. In chemistry, elements within a group exhibit characteristics that are alike. Every row on the periodic table, known as a period, reflects the distribution of electrons on energy shells around the nucleus. Therefore, elements are stacked on top of each other with similar properties when a new row is formed. Chemistry specialists often use gaps in the periodic table to establish the position and properties of each element. For instance, it could be deduced that both sodium and lithium have high reactivity energy with an oxidation state of +1. In a similar vein, beryllium is not a highly active element when compared to sodium and lithium but still retains metallic property.

It is very imperative for chemistry students to have a significant level of understanding of the concept of periodicity as it is, to a large degree, a fundamental framework upon which the chemical processes, reactions and principles can be meaningfully learnt. However, just like many concepts in chemistry, periodicity is often perceived as abstract and students find it difficult to grasp correctly (Achor et al., 2021; Bierenstiel & Snow, 2019; Franco-Mariscal et al., 2016; Gambari et al., 2016; Satilmis, 2014). Despite the significance of periodicity, the level of students' comprehension is still worrisome (Achor et al., 2021). The consequent of this is evident in was obvious in the West Africa Examination Council results of students between 2010-2018 (WAEC, 2018). It was additionally revealed that most chemistry students find it difficult to write various chemical formulae and balance given equations. This could be attributed to failure to be well grounded in periodicity.

The problems of students' retention of knowledge in chemistry is also obvious, worrying and calls for concern to the education stakeholders. Various research studies such as that of Achor et al. (2009), Ajayi and Ogbeba (2017) and Kurumeh et al. (2012) established the dismal retention capacity of students in chemistry in external examinations.

There is also evidence that chemistry students have challenges with the retention and recall of periodicity related concepts (Weiss et al., 2002). It is likely that this is a contributory factor to the poor outcomes among chemistry students in the senior secondary certificate examination. Coincidentally, Ezeudu and Obi (2013), Idika (2021) and Nbina and Vico (2010) submitted that although, efforts made through improved pedagogies to enhance students' learning outcomes in chemistry, their performances in examinations still remain worrisome. Regardless of the importance of chemistry in the advancement of society, it is seen that the achievement, as well as retention among chemistry students as reflected in their scores in the school examination is adjudged to be relatively low (Adzape et al., 2020; Bassey et al., 2005).

Furthermore, students' failure to retain and remember what has been learnt is largely linked to the teacher-centered methods that do not promote learners' active participation. The use of conventional teaching strategies, where chemistry teachers are sole-custodians and transmitters of knowledge, researchers say, mitigates effective learning (Gambari et al., 2016).

Similarly, Ekenobi et al. (2016) and Paden and Dereskiwsky (2007) provided empirical evidence showing that poor and inappropriate pedagogies are responsible for low knowldege retention rate among students. Hence, it is necessary to develop and employ contemporary, innovative methods for effective and efficient teaching and learning process, wherein the retention capacities of students are enhanced. Likewise, there is need to enhance active involvement of students in the teaching-learning processes for better academic outcomes (Okeke, 2018).

Conventional teaching strategy could be affirmed to be a rigid and non-productive approach as expected owing to continuous and repetitive way of presenting concepts thereby making it difficult to develop problem solving skills, cooperation and interaction between students and teachers, and it is often devoid of opportunities for students to relate what they have learnt to everyday life (Idika, 2021; Kaur, 2011; Nyamida, 2020). Therefore, for more effective teaching of chemistry concepts (periodic table), inventive and students' focused methodologies/approaches, which encourage problem solving and thinking as suggested. One of which is gamification (Mehta et al., 2017; Nyamida, 2020).

GAMIFICATION AS A LEARNING TOOL

Gamification is a vital instrument of learning, which can be used to arouse and increase the interest, attention and achievement of students in subject areas such as chemistry. Gamification relates the mode, values and incentives of engagement in games to learning situations (Arnold, 2014). It also describes the integration and use of gaming techniques and systems within a non-gaming environment to enhance learners'motivation and ease the stress of teaching-learning process. Arnold (2014) posited that gamification inolves game-thinking and game mechanisms to ensure active participation among learners and facilitate problem-solving in chemistry classrooms. Another researcher opined that gamification is not all about creating elaborate games but more about using the attributes of games to promote engagement, spur interest, stimulate skills, and new behaviours (Utendorf, 2013). Yayon et al. (2019) identified different categories of games in gamification, and these include escape rooms, written puzzles, puzzle games, monopoly games, and many others.

The use of puzzle (games) to enhancing concepts mastery has been recommended by the researchers and this has been established to boost academic achievement and knowledge retention capacity of chemistry students (Chen et al., 2001). For instance, the findings of Adzape et al. (2020), Fatokun et al. (2016), and Merrick, (2010) show that utilizing puzzle-based game learning as a pedagogical method can expand students' retention capacity, achievement, interest and level of active participation in the subject, and building up their basic reasoning and critical-thinking abilities. It is also established that students especially chemistry students additionally imbibe science processing skills such as observation, ordering, predicting, making inference, data recording and theorizing, when puzzle games are included (Achimugu, 2012). It was also noted that chemistry-related puzzles excite, keep up interest and fortify retention among chemistry students. Chemistry-based puzzles can be classified as edutainment (Michael & Chen, 2006). Games might be played for fun but still have elements of reasoning and educational features. For these reasons, puzzles were considered in this study.

Puzzle game is a constructivist, inquiry-based strategy model. Cambridge advanced learners dictionary defines a puzzle as a game or toy in which you need to fit together distinct pieces or problem, which should be answered by involving all domains of development. Gardiner (2006) comments that puzzle tackling ensures learning actively as it allows the participants to be engaged with tools and could have positive effect on students' retention and achievement. Chemistry games can empower students to interface and have a great time while they learn the chemical concepts. Utilizing games as reinforcement in the learning of periodicity can aid students to practice mental images and decrease uneasiness accordingly making learning permanent. Moore and Dettlaff (2005) also corroborated this and affirmed that it enhances the retention capacity of students.

Video-based puzzle strategy (VBPS) is an approach that involves the combination of visual representation of facts and interactive learning experiences so as to enhance knowledge application and make available simplified representation of periodicity in chemistry (Eskrootchi & Oskrochi, 2010). The use of this approach is characterized by creativity to teaching. This may involve hands-on and laboratory activities, cooperative and collaborative learning, discovery and inquiry, reflective thinking, and discussions to ensure uniform participation of students. VBPS in this study is the simulation type. Simulation is real-world like activities in a protective and conducive environment (Cecilia et al., 2019). Bello et al. (2016) established the significant impact of simulation game technique on students' learning performance. Therefore, this study sought to determine the impact of puzzle game strategy (PGS) and VBPS on students' achievement and retention in periodicity in secondary schools in Irewole Local Government Area of Osun State, Southwest, Nigeria.

Problem Statement

Periodicity is one of the fundamental concepts in chemistry upon which more advanced chemical concepts such as ionic theory, could be learnt and understood. It is, therefore, imperative that students have a significant level of understanding of the

Table 1. Analysis of covariance of post-achievement by treatment (PGS, VBP, & CS)

Source	Type III sum of squares	df	Mean square	F	Significance	Partial eta squared
Corrected model	811.941	6	135.324	46.169	0.000	0.620
Intercept	2,409.784	1	2,409.784	822.165	0.000	0.829
Pre-achievement	17.288	1	17.288	5.898	0.016	0.034
Treatment	610.811	2	305.405	104.198	0.000	0.551
Error	498.274	170	2.931		0.193	
Total	33,501.000	177				
Corrected total	1,310.215	176				

Note. R-squared=0.62 (adjusted R-squared=0.61) & *denotes significant p<0.05

arrangement of elements based on their characteristics. However, many students still experience some challenges in understanding periodicity (Achor et al., 2021; Bierenstiel & Snow, 2019; Franco-Mariscal et al., 2016; Gambari et al., 2016; Satilmis, 2014). Traditional teaching strategies, common among chemistry classrooms, are characterized by passive learning, which often leads to poor achievement. Hence, the advocacy for the integration of activity-oriented teaching methods. One of such is puzzle game. Constructivist-based games have been shown to improve students' learning outcomes by providing opportunities for learner's active engagement, visualization and applicability of knowledge. To this end, this study investigated the impact of puzzle games and video-based puzzle (VBP) games on students' learning outcomes (i.e., achievement and retention in periodicity).

Research Hypotheses

These null hypotheses were formulated and tested at 0.05 level of significance:

H1. There is no significant effect of treatment on senior secondary school students' academic achievement in periodicity in chemistry.

H2. There is no significant effect of treatment on senior secondary school students' retention in periodicity in chemistry.

MATERIALS & METHODS

This was a pre-/post-test, delayed post-test control group quasi experimental research design study. The manipulation of instructional strategy was done at three levels: PGS, VBPS, and conventional strategy (CS).The dependent variables include students' achievement in periodicity and students' retention in periodicity. The target population comprised all senior secondary school II (SSII) chemistry students. A multi-stage sampling procedure was adopted in selecting the participants for the study. Purposive sampling techniques was used to select six public secondary schools from Irewole Area of Osun State based on availability and willingness to participate in the study. Only schools, where SSII chemistry students were yet to be taught periodicity were considered. Two schools each were assigned to each treatment group (puzzle game n=68; VBP game n=60) and two schools were used as control (n=55). Intact classes were used. Therefore, the sample size comprising 183 senior secondary school chemistry students were drawn from six selected schools.

A total of seven research instruments (stimulus and response) were developed and used in the study. They are periodicity puzzle game guide (PPgG), periodicity video-based puzzle game guide (PSgG), conventional strategy instructional guide (CSIG), teacher evaluation sheet (TES), periodicity achievement test for senior secondary school students (PATSSS), and periodicity retention test for senior secondary school students (PRTSSS). After obtaining all necessary authorizations from the participating schools, the teachers of the experimental classes were assigned as research assistants. During a period of one week, the assistants were tutored on the steps and applications of puzzle and VBP games. Microteaching sessions were employed to assess the teachers' use of the treatment in a chemistry class. The following week, PATSSS was administered as pre-test to all the participating students. After which, treatment commenced. Periodicity was taught in two weeks. A reshuffled version of PATSSS was used as post-test while PRTSSS was administered after a space of two weeks to ascertain retention across the groups. Data collected was analysed using analysis of covariance and Bonferroni post-hoc analysis was used to show the direction or source of any significance. All hypotheses were tested at 0.05 level of significance (p<0.05).

RESULTS

H1. There is no significant effect of treatment on students' achievement in periodicity.

Table 1 revealed that treatment had a significant effect on students' achievement in periodicity ($F_{[2, 175]}$=104.20; p<0.05, partial η^2=0.55). **Table 1** indicated the effect size of 55%. This means that 55% of the total 61% variation observed (adjusted R^2=0.61) in students' post-achievement scores in periodicity was due to the significant effect of the treatment. Therefore, **H1** was rejected.

The magnitudes of the significant effect are presented in **Table 2**. **Table 2** revealed that students in PGS treatment group had the highest adjusted mean score in their post-achievement in periodicity (15.75) followed by those in VBP treatment group 2 (14.11) and CS control group (10.87). This order is represented; thus, PGS >VBP>CS.

Table 2. Estimated marginal means for post-achievement by treatment (PGS & VBP) & control group (CS)

Treatment (n)	Mean	Standard error	95% confidence interval	
			Lower bound	Upper bound
Puzzle game strategy (PGS) (68)	15.75	0.23	15.30	16.22
Video-based puzzle strategy (VBPS) (60)	14.11	0.24	13.65	14.58
Conventional strategy (CS) (55)	10.87	0.25	10.37	11.37

Table 3. Bonferroni post-hoc analysis of post-achievement by treatment (PGS, VBP, & CS)

(I) Treatment	(J) Treatment	Mean difference (I-J)	Significance
Puzzle game strategy (PGS)	Video-based puzzle starategy (VBPS)	1.638*	.000
	Conventional strategy (CS)	4.883*	.000
Video-based puzzle strategy (VBPS)	Puzzle game strategy (PGS)	-1.638*	.000
	Conventional strategy (CS)	3.244*	.000
Conventional strategy (CS)	Puzzle game strategy (PGS)	-4.883*	.000
	Video-based puzzle strategy (VBPS)	-3.244*	.000

Note. *denotes significant p<0.05

Table 4. Analysis of covariance of retention by treatment (PGS, VBP, & CS)

Source	Type III sum of squares	df	Mean square	F	Significance	Partial eta squared
Corrected model	1,235.375	6	205.896	68.063	0.000	0.706
Intercept	334.493	1	334.493	110.573	0.000	0.394
Pre-achievement	1.077	1	1.077	0.356	0.552	0.002
Treatment	441.909	2	220.954	73.041	0.000	0.462
Error	514.263	170	3.025		0.000*	
Total	25,655.000	177				
Corrected total	1,749.638	176				

Note. R-squared=0.71 (adjusted R-squared=0.70) & *denotes significant p<0.05

Table 5. Estimated marginal means for retention by treatment (PGS & VBP) & control group (CS)

Treatment (n)	Mean	Standard error	95% confidence interval	
			Lower bound	Upper bound
Puzzle game strategy (PGS) (68)	14.53	0.29	13.97	15.09
Video-based puzzle strategy (VBPS) (60)	11.98	0.24	11.50	12.46
Conventional strategy (CS) (55)	8.45	0.33	7.80	9.09

Table 6. Bonferroni post-hoc analysis of retention by treatment (PGS, VBP, & CS)

(I) Treatment	(J) Treatment	Mean difference (I-J)	Significance
Puzzle game strategy (PGS)	Video-based puzzle starategy (VBPS)	2.553*	.000
	Conventional strategy (CS)	6.083*	.000
Video-based puzzle strategy (VBPS)	Puzzle game strategy (PGS)	-2.553*	.000
	Conventional strategy (CS)	3.529*	.000
Conventional strategy (CS)	Puzzle game strategy (PGS)	-6.083*	.000
	Video-based puzzle strategy (VBPS)	-3.529*	.000

Note. *denotes significant p<0.05

Table 3 indicated that the post-achievement mean score in periodicity of students in PGS was significantly different from those in the modified conventional and the conventional strategies. Also, the difference in the post-achievement mean scores of students in VBP and those in CS was significant. This further shows that the difference between the treatment groups (puzzle game and modified conventional strategies) and between the treatment groups and the control group is significant.

H2. There is no significant effect of treatment on students' retention in periodicity.

Table 4 showed that the effect of treatment on students' retention in periodicity ($F_{[2, 175]}$=73.04; p<0.05, partial η^2=0.46) was significant. **Table 4** showed the effect of 46%, which implies that 46% of the variation in students' retention scores in periodicity was as the result of the significant main effect of the treatment. Therefore, **H2** was rejected.

Table 5 revealed that students in PGS treatment group had the highest adjusted mean score in their retention in periodicity (14.53) and VBP treatment group 2 (11.98) and CS control group (8.45). This order is represented; thus, PGS >VBP>CS.

Table 6 indicated that the retention mean score of students in PGS was significantly different from those in VBPS and CS. While the difference in the retention mean scores of students in VBPS and those in CS was also significant. Invariably, this indicates that the significant difference observed was due to the variance between the treatment groups (puzzle game and modified conventional strategies) and also between the treatment and the control, with regards to students' retention scores in periodicity.

DISCUSSION

Generally, the findings of this study showed that the puzzle-based instructional strategies had a considerable impact on students' achievement in periodicity. The post-test scores of students' achievement in periodicity differs significantly across the treatment group and control group. The students in puzzle-game group obtained the highest achievement mean score (15.75) followed by students in VBPS mean score (14.11) and those in CS control group (10.87). One can therefore infer that both PGS and VBPS are more efficacious in improving students' achievement in periodicity than the conventional teaching strategy. This could be because both experimental treatments are learner-centered and experiential approaches. Generally, experiential approach has been established to enhance students' outcomes (Hassan & Poopak, 2012; Idika, 2021).

On puzzle-game, the findings of this study corroborate those of Bahrami et al. (2012), Ezeudu and Ezinwanne (2013), Fatokun et al. (2016), Hassan and Poopak (2012), Poripo (2008), and Umoke and Nwafor (2014), who revealed that the experimental groups had higher scores in achievement utilizing instructive games. This affirms that the use of games in chemistry education has positive impacts on the achievements of the students. Furthermore, the responses of some students revealed that the application of edutainment games enhance their interest, achievement and retention in chemistry. However, the findings of this study vary with that of Adzape et al. (2020) who revealed that the variation in mean achievement scores of students exposed to chemical periodicity with periodicity-based puzzles and those taught with demonstration method was not significant.

It is also evident that treatment used in this study can impact significantly on students' retention in periodicity. With regards to students' retention in periodicity, the post-test performance differed significantly across the treatment group and control group. The students assigned to puzzle-game group obtained the most retention mean score (14.53) followed by students in VBPS mean score (11.98) and those in CS control group (8.45). One can therefore infer that both PGS and VBPS can enhance students' retention in periodicity than the conventional teaching strategy. This could be because of both puzzle-game and video-based strategies learner-centered and experiential approaches. The findings of this study clearly support those of Agu and Samuel (2018), Ezeudu and Ezinwanne (2013), Fatokun et al. (2016), Selvi and Cosan (2018), Uche et al., (2016), and Umoke and Nwafor (2014).

The main essence of a teaching method includes ensuring effective and efficient presentation of facts and ideas to ensure students' retention, interest and academic achievement in chemistry. Chemistry teachers should ensure that chemistry concepts are taught with 21st century learner-centered and digital skills. Chemistry lessons should be knowledge-based, activity-based student centered for effective mastery and retention.

CONCLUSIONS

Games have been shown to encourage the conceptualization of principles in abstract subjects such as chemistry. Some evidence exist that instructional strategies, which engage learners actively and provide deep learning experience such as puzzle game and VBP game have a considerable potential to enhance students' achievement and retention in difficult chemical concepts like periodicity in chemistry.

Recommendations

The results of this study provide basis for the following recommendations:

1. Chemistry educators should be skilled on how to design simple games for teaching various concepts to make learning less abstract.
2. Teacher training schools should be updated with current and contemporary approaches in teaching and learning periodicity.
3. Puzzle games should be employed in periodicity classes to improve students' learning outcomes.

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REFERENCES

Achimugu, L. (2012). Strategies for effective conduct of practical chemistry works in senior secondary schools in Nigeria. *Journal of Science Teachers Association of Nigeria, 47*(1), 126-136.

Achor, E. E., Imoko, B. I., & Uloko, E. S. (2009). Effect of ethno-mathematics teaching approach on senior secondary students' achievements and retention in locus. *Educational Research and Review, 1*(8), 386-390.

Achor, E. E., Otor, E., & Kalu, R. (2021). Boosting achievement of senior secondary school two students in selected difficult concept in chemistry concept using assertive questioning and prior knowledge of behavioural objectives strategies. *International Journal of Education Learning and Development, 9*(4), 9-29.

Adzape, J. N., Otor, E. E., & Akpoghol, T. V. (2020). Effects of chemistry-based puzzles on senior secondary school chemistry students' achievement and gender in chemical. *Education and Linguistics Research, 6(2)*, 88-100. https://doi.org/10.5296/elr.v6i2.17836

Agu, P. A., & Samuel, I. R. (2018). Effects of simulation instructional package on basic science and technology students' achievement and retention in Federal Capital Territory Abuja, Nigeria. *International Journal of Innovative Education Research, 6*(3), 1-7.

Ajayi, O. V., & Ogbegba, J. (2017). Effect of gender on senior secondary school chemistry students' achievement in stoichiometry using hands-on asctivities. *American Journal of Educational Research, 5*(8), 839-842. https://doi.org/10.12691/education-5-8-1

Arnold, B. J. (2014). Gamification in education. *Proceedings of ASBBS, 21*(1), 32-39.

Bahrami, F., Chegini, Z. R., Kianzadeh, A., Emami, F., & Abdi, H. (2012). A comparison of the effectiveness of game-based and traditional teaching on learning and retention of first grade mathematics concept. *European Journal of Experimental Biology, 2*(6), 2099-2102.

Bassey, V. V., Asim, A. E., & Essien, M. I. (2005). A trend analysis of African senior secondary certificate examination results in science, technology and mathematics implications for instructions in Nigerian secondary schools. In *Proceedings of the 31st Assessment*.

Bello, S., Ibi, M. B., & Bukar, I. B. (2016). Effects of simulation techniques and lecture method on academic performance of Mafoni Day secondary school Maduguri, Borno State. *Journal of Education and Practice, 7*(23), 113-117.

Bierenstiel, M., & Snow, K. (2019). Periodic universe: A teaching model for understanding the periodic table of element. *Journal of Chemical Education, 96*(7), 1367-1376. https://doi.org/10.1021/acs.jchemed.8b00740

Cecilia, O. N., Bernedette, V., & Richard, V. (2019). Effects of simulation instructional method on undergraduate periodicity education students, performance in sodium reactions.

Chen, A., Darst, P. W., & Pangrazi, R. P. (2001). An examination of situational interest and its sources. *British Journal of Educational Psychology, 71*(Pt 3), 383-400. https://doi.org/10.1348/000709901158578

Ekenobi, T. N., Mumuni, A. A. O., & Nwanekezi, A. U. (2016). Enhancing periodicity student, retention of redox reaction concept through intention with advance organizers. *British Journal of Psychology Research, 4*(4), 34-46.

Eskrootchi, R., & Oskrochi, G. R. (2010). A study of efficacy of project based learning integrated science with computer based simulation. *Educational Technology and Society, 13*(1), 236-245.

Ezeudu, F. O., & Ezinwanne, O. P. (2013). Effects of simulations on students' achievement in senior secondary school chemistry in Enugu East Local Government Area of Enugu State, Nigeria. *Journal of Education and Practice, 5*(19), 2014-2101.

Ezeudu, F. O., & Obi, T. N. (2013). Effect of gender and location on student achievement in periodicity in secondary schools in Nsukka Local Government Area of Enugu, Nigeria. *Research on Humanities and Social Sciences, 3*(15), 50-55.

Fatokun, K. V. F., Egya, S. O., & Uzoechi, B. C. (2016). Effects of game instructional approach on students academic and retention in periodicity. *European Journal of Research and Reflection in Educational Sciences, 4*(7), 29-40.

Franco-Mariscal, A. J., Oliva-Martinez, J. M., Blanco-Topez, A., & Espana-Ramos, E. (2016). A game based approach to learning the idea of chemical elements and their periodic classification. *Journal of Chemical Education, 93*(7), 1173-1190. https://doi.org/10.1021/acs.jchemed.5b00846

Gambari, I. A., Gbodi, B. E., Olasunkanmi, E. U., & Abalaka, E. N. (2016). Promoting intrinsic and extrinsic motivation among chemistry students using computer assisted instruction. *Contemporary Educational Technology, 7*(1), 25-46. https://doi.org/10.30935/cedtech/6161

Gardiner, P. L. (2006). *Mathematics puzzling*. Dover Publications.

Hassan, R., & Poopak, M. (2012). The effect of card games and computer games on learning of chemistry concept. *Procedia Social and Behavioural Science, 31*, 597-601. https://doi.org/10.1016/j.sbspro.2011.12.111

Helmenstine, A. (2021). *Periodicity definition in chemistry*. https://sciencenotes.org/periodicity-definition-in-chemistry/

Idika, M. I. (2021). Effect of visualized case-based learning strategy on students' academic performance in chemistry in Ibadan Metropolis, Nigeria. *African Journal of Teacher Education, 10*(1), 106-126. https://doi.org/10.21083/ajote.v10i1.6281

Kaur, G. (2011). Study analysis of lecture model of teaching. *International Journal of Educational Planning and Administration, 1*(1), 9-13.

Kurumeh, M. S., Onah, C. O., & Muhammed, S. (2012). Improving students' retention in junior secondary school statistics using ethnomathematics teaching approach inn Obi and Olu Local Government Area of Benin, Edo State, Nigeria. *General Journal of Educational Research, 2*(3), 54-62. https://doi.org/10.15580/GJER.2012.3.10051286

Mehta, G., Tunks, K., Sanagapaty, K., & Pal, A. (2017). Constructing knowledge in an interactive game-like design environment for STEM education. *International Journal ofInformation and Education Technology, 7*(8), 566-570. https://doi.org/10.18178/ijiet.2017.7.8.932

Merrick, K. A. (2010). An empirical education of puzzlebased learning as an interest approach for teaching introductory computer science. *IEEE Transactions on Education, 53*(4), 677-680. https://doi.org/10.1109/TE.2009.2039217

Micheal, D. R., & Chen, S. (2006). *Serious games: Games that educate, train, and inform*. Thomson Course Technology.

Moore, L. S., & Dettlaff, A. J. (2005). Using educational games as a form of teaching in social work. *Arete, 29*(1), 58-72.

Nbina, J., & Vico, B. (2010). Effect of instruction in metacognitive self-assessment strategy on chemistry self-efficacy and achievement of senior secondary school students in Rivers State, Nigeria. *Academic leadership: The Online Journal, 8*(4), 19. https://doi.org/10.58809/ITME4108

Nyamida, A. (2020). *Discussion and lecture method in chemistry. Effects on the performance of senior secondary two students*. https://www.grin.com/document/915056

Okeke, O. J. (2018). Interaction effect of gender and treatment on mean retention score of chemistry students taught using mend mapping teaching strategy in Enugu. *International Journal of Research in Engineering and Applied Sciences, 8*(10), 25-42.

Paden, R. R., & Dereskiwsky, M. I. (2007). *A comparison of students achievement and retention in introductory math course delivered in online, face-to-face, and blended modalities* [Paper presentation]. The Teaching, Colleges and Community Worldwide Conference.

Poripo, J. (2008). *Effects of simulation on male and female students' achievement in chemistry in Bayelsa State, Nigeria*. Izontimi Publisher.

Satilmis, Y. (2014). Misconceptions about periodicity in senior secondary chemistry education: A case of Kazakhstan. *International Online Journal of Primary Education, 3*(2), 53-58.

Selvi, M., & Cosan, A. O. (2018). The effect of using educational games in teaching kingdoms of living things. *Journal of Educational Research, 6*(9), 2019-2028. https://doi.org/10.13189/ujer.2018.060921

Uche, A., Muhammed, A., Asogwa, E. N., & Ofoegbu, T. (2016). Effect of interactive computer simulation package on senior secondary school students' achievement and retention in genetics concepts. *Asian Journal of Information Technology, 15*(14), 2313-2321.

Umoke, J. C., & Nwarfor, C. C. (2014). Effectiveness of instructional simulation on secondary school students achievement in biology. *Journal of Education and Practice, 5*(19), 222-288.

Utendorf, H. (2013). *What does gamification mean?* Intrepid Learning.

Weiss, R. E., Knowhton, D. S., & Morrison, G. R. (2002). Principles for using animation in computer-based instructional theoretical heuristic for effective design. *Computers in Human Behavior, 18*(4), 465-477. https://doi.org/10.1016/S0747-5632(01)00049-8

WAEC (2018). *Chief Examiner's Report*. West African Examination Council.

Yayon, M., Rap, S., Adler, V., Haimovich, I., Levy, H., & Blonder, R. (2019). Do it yourself: Creating and implementing a periodic table of the elements chemical escape room. *Journal of Chemical Education, 97*(1), 132-136. https://doi.org/10.1021/acs.jchemed.9b00660