Effects of VAK Learning Style Preferences on Senior School Students' Performance in Chemistry in Ilorin, Nigeria

Hauwa Ajibola SALIHU
Department of Science Education,
Faculty of Education, University of Ilorin, Nigeria
jibolasani@gmail.com

Khadijat Saka AMEEN
Department of Science Education,
Faculty of Education, University of Ilorin, Nigeria
ameen.sk@unilorin.edu.ng

Abstract

The study determined the effects of VAK learning style preferences on senior school students' performance in isomerism. The study employed a quasi-experimental, non-randomized, non-equivalent pretest, posttest control group design. Two senior schools were purposively selected from Ilorin South Local Government Area, Kwara State, Nigeria. 111 participants were drafted into the visual, auditory and kinesthetic (VAK) classrooms and 86 participants into the control classroom with a Preferred VAK Chemistry Classroom Checklist (PVC^3). Data was collected with Isomerism Assessment Test for pretest and was reshuffled for posttest. Additional data was collected using the Perception of Learners on VAK Classrooms Questionnaire (PLVCQ). Reliability indices of 0.77 and 0.79 were obtained for the IAT and PLVCQ, respectively, using Many-Facet Rasch Measurement (MFRM) and Cronbach's Alpha. Research questions were answered using percentage, mean and standard deviation, while hypotheses were tested using ANCOVA at 0.05 significant level. Findings revealed that there was no significant difference in performance among the three VAK classrooms but a significant comparative effectiveness in performance of learners in all the VAK classrooms against the control group. In addition, all the learners perceived the learning intervention to be relevant to their study. The study concluded that VAK learning styles are effective for learning isomerism. The study, therefore, recommended that learners should be encouraged to choose and use their preferential learning style to study, in pursuit of a better academic performance.

Keywords: VAK learning styles; Perception, Performance.

Introduction

Chemistry has been identified as a core science subject that plays leading role in a nation's physical and economic growth through its principles of chemical industries and its relationship with a sustainable environment and life (Ibrahim et al. 2017). Chemistry allows learners to connect classroom activities with those activities outside the classroom through the content of the chemistry curriculum. Aji (2022) mentioned that the aim of teaching secondary school chemistry is to avail the learners of the relevant knowledge and practical skills for both human and national growth, thereby making the learners functional members of society.

The VAK learning styles are diverse ways of learning engaged in by learners to improve their understanding of the concepts under review. They are unique education styles that enable learners to process given information and comprehend the information quickly (Sreenidihi & Tay, 2017). Mislina and Hazmilah (2017), identified these learning styles as peculiar conditions which permit the learners to perceive, process, store and recall a desirable concept in the best way. The VAK learning styles are connected to three human faculties: sight (visual); hearing (auditory); and touch or movement (kinesthetic). The visual learners prefer to learn through visual channels like video, bulletin boards, movies, displays, diagrams and pictures (Engage Education, 2023; Bakri et al. 2019; Gholami and Bagheri 2013). These learners focus on nonverbal cues to learn. The auditory learners learn by having discussions, conversations, reading aloud in the classrooms, listening and repetitions. These learners take cues from verbal instructions and interpret information by studying the tone, emphasis, and speed of the speaker. Kinesthetic learners prefer to undertake a new task by trying it out themselves. They learn fast through experiments in the laboratory, setting up a set of apparatuses and sporting equipment and so on (Bakri et al. 2019).

Studying the different learning styles and preferences of the learners may assist in improving learners' cognitive abilities. Learning style preferences have been reported to significantly improve learning, enable learners to work on their weaknesses and grow their learning modalities strengths (Sumitha & Prasadh, 2022). VAK learning style assists the learners in selecting preferred learning style and utilising this to organize the process of learning. It helps the students to identify and connect with the subject content in such a manner that will bring out the best in learning outcomes (Abel & Medhat, 2016).

Over the years, it has been established that VAK learning styles play an important role in the learning process. Every individual has a particular learning style that shows how interaction with the learning environment plays out. Learning styles research is often based on the theory that individuals have different stimulus sense modalities, from which they prefer to absorb, retain and process new information (Moussa, 2014).

In a cross–sectional study carried out in various nursing and health research institutions in Iran, Kouhan et al. (2021) examined the relationship between the dominant learning styles of virtual nursing and midwifery students and their academic performance. The research participants were enrolled in a convenient sampling method. The researchers employed the use of the VARK learning style questionnaire as an instrument for data collection. The findings from the study revealed that the dominant learning style was kinesthetic, followed by auditory and visual learning styles respectively. In addition, the chi–square assessment study revealed that there was no

statistically significant difference between the dominant learning style and academic performance of strong and weak nursing students.

Abidoye and Olorundare (2020) investigated the correlation between learning styles and biology learning performance of Nigerian senior school students in Ifelodun Local Government Area (LGA) of Kwara State. The study was a descriptive survey research and participants were randomly selected. The researchers used Grasha and Reichmann's students learning scale and VAK/VARK learning style to collect data. Using percentage, the Pearson product-moment correlation and chi-square tests, the study revealed that there was a negative correlation between students' academic performance and visual and kinesthetic learning styles and a positive correlation with the auditory learning style. Secondly, the study revealed that most of the research respondents preferred the visual learning style more than the auditory and kinesthetic learning styles.

Bakri et al. (2019) explored the impact of the VAK learning style on teenager-level language learners at a secondary school in Indonesia and purposively recruited samples that had average English language speaking ability based on the evaluation of the previous semester's marks. The study, which was a pre-experimental research design, employed the one-group pretest-posttest design for the participants. Results from the *t*–test calculated values showed the use of the VAK learning style activity was significantly effective on the speaking ability of the tested subjects. This is because the adoption of the VAK learning style activity impacted the students' learning achievements and improved their confidence in speaking skills.

Almomani (2019), a researcher at the King Saud University of Saudi Arabia, investigated the preferred cognitive learning patterns (VAK) among secondary students admitted to King Saud University and its effect on their academic achievement in physics. The research was a descriptive survey study and the participants were drawn randomly for the research. Data was collected with a researcher-designed scale of cognitive learning pattern. Results from the study showed that most of the newly admitted students preferred the visual learning pattern and the kinesthetic learning pattern was least preferred, however, the students who preferred the kinesthetic learning style had the highest achievement in the study while the auditory students had the least achievement. Importantly, the study revealed a statistically significant effect of learning patterns on students' achievement in physics.

Individuals have different cognitive abilities and therefore respond to or perceive new information differently. Perception of information begins with the human senses directly and proceeds to the use of cognitive skills to interpret what was experienced (University of Wisconsin-

Madison, 2024). A study conducted to examine learners' perception of learning support in a blended organic chemistry classroom reported that learners perceived the learning support to be relevant as it availed them the chance to learn, rehearse and go through the day's lessons at their own pace and convenience (Tekane et al. 2020). In another submission, it was reported that the learners strongly responded to the different learning styles, registered a sense of collaboration with other learners and that learning and discussion were improved among the students when facilitators exposed them to different learning styles (Bhagat et al. 2015).

Theoretical Framework

The study is based on the Learning Modality Theory by Barbe et al. (1979), which states that perception, memory and sensation comprise the concept of modality and these learning modalities are the sensory channels or pathways through which individuals give, receive and store information. These modalities or senses include visual, auditory, tactile/kinesthetic, which was later coined to be the VAK Learning Theory. It was discovered that learners demonstrated approximately 30% visual strength, 30% mixed strength, 25% auditory strength and 15% kinesthetic strength. These learning channels play important role in the nature and quality of learning and academic performance may improve when learners choose and study with their preferential learning styles.

Statement of the Problem

Learners' inability to understand certain chemistry concepts, which is evident in poor performance in external examinations, can undermine the importance of chemistry in the long run. Poor performance is a reflection that learners find it difficult to learn and understand basic concepts and are unable to apply what they have learnt in the examination. This may stem from the broadness and abstract nature of these chemistry concepts (Kyado et al. 2021; Worokwu, 2016). One of such chemistry concept perceived to be difficult by the learners is stereochemistry (isomerism) (Oladejo et al. 2023; Jack et al. 2017). West African Examination Council (WAEC) Chief Examiner's Report (2022) stated that stereochemistry questions were not satisfactorily answered by the learners as they were unable to provide the conventional names of some isomers in questions and also found it difficult to draw the structures of the other isomers (WAEC, 2022). To this end, educational researchers have studied different methods of engaging learners more in their studies by introducing various learning strategies to understand the situation and seek better performance for the learners. It is imperative to conduct this study to determine the effects of VAK learning styles on learners' academic performance.

Purpose of the Study

The main purpose of this study was to determine the effects of VAK learning style preferences on senior school students' performance in chemistry. Specifically, the study determined the:

1. preferential learning style of the chemistry learners;
2. comparative effectiveness of VAK learning styles on the academic performance of chemistry learners;
3. comparative effectiveness of VAK learning styles and the lecture method on the post-treatment performance of the chemistry learners;
4. perception of the learners regarding the relevance of the VAK learning styles to their study.

Research Questions

1. What is the preferential learning style of the chemistry learners?
2. What is the comparative effectiveness of VAK learning styles on the academic performance of chemistry learners?
3. What is the comparative effectiveness of VAK learning styles and the lecture method on the post-treatment performance of the chemistry learners?
4. What is perception of the learners regarding the relevance of the VAK learning styles to their study?

Research Hypotheses

H_{01}: There is no significant difference in the comparative effectiveness of the VAK learning styles on the academic performance of the chemistry learners.

H_{02}: There is no significant difference in the comparative effectiveness of the VAK learning styles and the lecture method on the post treatment performance of the chemistry learners.

Methodology

The study was a quasi-experimental research involving a 4 x 2 pre-test, post-test, non-randomised, non-equivalent, control group design. That is, three experimental groups (visual classroom, auditory classroom, and kinesthetic classroom), a control group, and two levels (relevant and not relevant) of learners' perception. The target population was all SSS II students offering chemistry in the Ilorin South Local Government Area of Kwara State, Nigeria. The final sample for the study consisted of 197 SSS II students from two (2) intact classes of the two (2) selected schools. This comprised of 111 learners for the three VAK classrooms (25 learners in the visual classroom, 26 learners in the auditory classroom and 60 in the kinesthetic classroom). The

control group consisted of 86 learners. Two secondary schools were purposively selected for the study. This selection was made due to high government contiguity in the schools. The schools also had separated science laboratories that accommodated the participants for the three VAK learning styles classrooms and the control group. This was important for the study as interference amongst the study participants must be limited to the barest minimum.

Assigning participants into the various classes was achieved with the 'Preferred VAK Chemistry Classroom Checklist (PVC^3), a 15-item multiple-choice checklist adapted from the VAK Learning Styles Self-Assessment Questionnaire by Chislett and Chapman (2005) and Reid's Perceptual Learning Style Preference Questionnaire of 1987. The checklist had options a, b, and c. The learners picked the most appropriate options applicable to them. If a student picked more of option 'a', such student was assigned to the visual classroom. This pattern was applicable to auditory (b) and kinesthetic (c) learners.

Data was gathered from the administration of a 20-item multiple choice questions Isomerism Assessment Test (IAT), as pre-test, which was reshuffled and re-administered as a post-test, on all the three VAK classrooms and the control group. The IAT questions were extracted from the content of the learning intervention materials and had options a- d. Learners picked the most appropriate option. Data on perception was collected from the Perception of Learners on VAK Classroom Questionnaire (PLVCQ). The PLVCQ, also had one section which was a researcher–developed 10 item-list, to determine the perception of the learners in the VAK chemistry classrooms. These items were set to determine how relevant the research interventions were to the learners' study. The PLVCQ had response modes of Strongly Disagree, Disagree, Agree and Strongly Agree (Vagias, 2006).

The intervention materials employed were the Visual Classroom Mute on Sound (MOS) Isomerism Video (VCMIV), the Auditory Classroom Isomerism Audio (ACIA), and the Kinesthetic Classroom Kit. In addition, were lesson plans for all three VAK classrooms and the control group, developed based on the content of the senior secondary school chemistry curriculum on isomerism. The visual classroom MOS isomerism video was a 16 minutes long video that featured both text and AI generated motion diagrams, highlighting the content of the lesson plan on isomerism from introduction stage through to the step by step formation of different isomers to summary representation of the whole content. The video was displayed on the whiteboard from a projector machine attached to the researcher's computer system.

The auditory classroom isomerism audio was a 26 minutes long self-recorded audio based on the content of MOS video and the lesson plan. The audio was later enhanced by the sound

engineer for equalization, dynamics, clarity and timing. The audio was saved on the flash and played for the auditory learners from an outdoor wireless speaker. The kinesthetic classroom kit was an ensemble of colourful ball-and-stick molecular models made from plastics. These models represent different elements on the periodic table but relevant to the study. This ensemble also consists of printed colored cards illustrating the content of the lesson plan on isomerism and instruction of what the learners needed to do.

Three periods were used in each school from the pretest stage to the post-test stage. During the first period, the PVC^3 was administered for the participants to be assigned based on their VAK chemistry classroom preferences. The multimodal students were assigned to the control group. Simultaneously, the IAT was distributed to test the students' knowledge of isomerism. This served as the pre-test. The content of the intervention instruments (VCMIV, ACIA, the Kinesthetic Classroom Kit and the control group package) was delivered during the second period, at the same time, with the help of three assistants. The researcher was available in the control group classroom and taught isomerism with the lecture method. On the third visit, the reshuffled IAT which served as the post-test and the PLVCQ were administered to the students simultaneously. All ethical practice concerning procedure of research, safety of the participants, confidentiality of the participants, purpose, benefits and rights of the volunteer were intentionally observed in the course of the research.

The content validity of all the instrument and intervention materials was carried out by experts from Departments of Science Education and Educational Technology, Faculty of Education, University of Ilorin, and chemistry teachers who have had 10 years working experience. The reliability index of the IAT and PLVCQ was 0.77 and 0.79 respectively. This was obtained using the Many-Facet Rasch Measurement (MFRM) which revealed the difficulty index and discriminating index of the IAT and Cronbach's Alpha. Research questions were answered using percentage and mean, while hypotheses were tested using the ANCOVA at 0.05 level of significance

Results

Research Question 1: What is the preferential learning style of the chemistry learners?

Table 1: Percentage of learners in all VAK classrooms

VAK classrooms	Number (N)	Percentage (%)
Visual	25	22.52
Auditory	26	23.43
Kinesthetic	60	54.05
Total	111	100

Table 1 indicates that the learners preferred the kinesthetic classroom most with a 54.05%, followed by the auditory classroom (23.43%) and, finally the visual classroom (22.52%).

Research Question 2: What is the comparative effectiveness of VAK learning styles on the academic performance of chemistry learners?

Table 2: Comparative effectiveness of the VAK learning styles on the academic performance of the chemistry learners

			Pretest		Posttest	
Groups	**N**	**%**	**M**	**SD**	**M**	**SD**
Visual	25	22.52	4.68	1.31	10.16	3.13
Auditory	26	23.43	4.23	2.39	10.00	2.33
Kinesthetic	60	54.05	4.50	1.86	9.43	2.21
Total	111	100	4.48	1.89	9.73	2.47

N = number of learners

Table 2 reveals the mean (M) pretest and post-test scores, and the standard deviation scores of the learners. The Visual learners had the highest post-test mean score of 10.16, followed by the Auditory learners (10.00) and finally the Kinesthetic learners (9.43) against a pretest mean scores of 4.68, 4.23 and 4.50, respectively. This result indicates that the mean post-test scores were higher than the mean pretest scores.

H_{01}: There is no significant difference in the comparative effectiveness of the VAK learning styles on the academic performance of the chemistry learners.

Table 3: ANCOVA results of the comparative effectiveness of the VAK learning styles on the academic performance of the chemistry learners

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.
Corrected Model	21.14[a]	3	7.05	1.16	0.33
Intercept	1358.28	1	1358.28	223.33	0.00
Pretest	9.34	1	9.34	1.54	0.22
VAK	11.85	2	5.92	0.97	0.38
Error	650.75	107	6.08		
Total	11180.00	111			
Corrected Total	671.89	110			

p>0.05 (0.38), not significant

Table 3 shows the ANCOVA results of the comparative effectiveness of the VAK learning styles on the academic performance of the chemistry learners. The results indicate that there was no significant difference in the academic performance among the three VAK classrooms F (1,107) = 0.97; $p > 0.05$. This is because the p-value of 0.38, obtained, was greater than 0.05 significant level.

Research Question 3: What is the comparative effectiveness of VAK learning styles and lecture method on the post-treatment performance of the chemistry learners?

Table 4: Comparative effectiveness of VAK learning styles and lecture method on post-treatment performance

Groups	N	Pretest Mean	SD	Post-test Mean	SD	Mean gain difference
Visual	25	4.68	1.31	10.16	3.13	5.48
Auditory	26	4.23	2.39	10.00	2.33	5.77
Kinesthetic	60	4.50	1.86	9.43	2.21	4.93
Control	86	4.26	2.31	8.13	2.91	3.87

N = number; SD = standard deviation

Table 4 shows the mean scores (M), the standard deviation (SD) scores, and the mean gain difference of the learners in the VAK classrooms against that of the control group. The three experimental groups had the mean gain difference of 5.48, 5.77 and 4.93 respectively while the control had 3.87 as the mean gain difference.

H_{02}: There is no significant difference in the comparative effectiveness of the VAK learning styles and lecture method on the post treatment performance of the chemistry learners.

Table 5: ANCOVA analysis of the post treatment performances of the VAK learning styles and lecture method on the academic performance of the chemistry learners

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.	Partial Eta Squared
Corrected Model	393.14[a]	2	196.57	28.23	.00	.23
Intercept	1548.31	1	1548.31	222.34	.00	.53
Pretest	189.05	1	189.05	27.15	.00	.12
Treatment	42.67	1	42.67	6.13	.01	.03
Error	1350.94	194	6.96			
Total	18725.00	197				
Corrected Total	1744.08	196				

p<0.05 (0.01), significant

Table 5 shows the ANCOVA results which indicate that there was a significant difference in the post-treatment performance of the chemistry students when taught using VAK learning styles: F (1,194) = 6.13; $p < 0.05$. This is because the p-value of 0.01 is less than 0.05 level of significance. This implies that learners taught using VAK learning styles had better performance in chemistry than that those taught using lecture method.

Research Question 4: What is perception of the learners regarding the relevance of the VAK classrooms instructional strategies to their study?

Table 6: Perception of learners on the relevance of the VAK learning styles to their study

VAK Learners	Number of learners	Mean	Standard Deviation
Visual learners	25	30.16	1.72
Auditory learners	26	30.19	1.96
Kinesthetic learners	60	29.40	2.20
Total	111	29.76	2.06

Table 6 shows the mean values of perception of the learners to the VAK chemistry classroom strategies after the intervention. The mean values of Visual learners were (*M*=30.16; *SD*=1.70), the Auditory learners had a mean score of (*M*=30.19; *SD*=1.96), while Kinesthetic learners had the mean values of (*M*=29.40; *SD*=2.20).

Discussion of Findings

The findings from the preference results revealed that the kinesthetic classroom instructional setting was most preferred by the learners. This preference could be that most science learners are more drawn to hands-on-materials than just taking notes in class. Additionally, the results revealed that there was no significant difference in the academic performance among the visual, the auditory and the kinesthetic classrooms. The reason for this result may be linked to an increased understanding of the content of learning through the intervention. This result tallied with the study findings of Kouhan et al. (2021), who reported a dominant preference for the kinesthetic learning style and a no significant difference among the three learning modalities but this is in contrast with the findings of Abidoye and Olorundare (2020) and Almomani (2019), who all reported that the visual learning style was most preferred among the respondents of the studies.

The post-treatment results obtained showed that the experimental groups, (the visual, the auditory and the kinesthetic classrooms) had higher mean post-treatment scores when compared with the learners in the control group and a higher mean gain difference as against the control group. The reason for this high difference could be the learners' understanding of the intervention materials as well as the interest for the VAK learning styles classrooms which were different from their regular classes. This contributed to the positive academic performance of the learners in all the three VAK classrooms. Further results also revealed that there was a statistically significant difference in the post treatment performance of learners in the three VAK classrooms as against those in the control group. This finding is in agreement with the findings of Bakri et al. (2019) and

Almomani (2019), who reported significant relationships between academic performance and the VAK learning styles. However, this report is in contrast with the findings of Kouhan et al. (2021), and Abidoye and Oloundare (2020), who reported a negative correlation between VAK learning styles and academic performance.

Finally, all the learners in the three VAK classrooms perceived the intervention to be relevant to their study. This can be attributed to the fact that the learning contents were extracted from the lesson plan prepared for their level of study. This is line with the submissions of Bhagat et al. (2015) and Tekane et al. (2020) who reported that learners in their studies perceived the learning support to be relevant as it availed them the chance to learn, rehearse and go through the day's lessons at their own pace and convenience.

Conclusion

The research was carried out to investigate the effects of VAK learning styles preferences on learners' academic performance in chemistry and determining the perception of the learners on the relevance of the intervention materials to their study. The study concluded that the Kinesthetic classroom was more preferred by the learners and that the learners in the three VAK classrooms had higher post-treatment scores than the control group with a significant result, hence, the learning intervention yielded a positive result in terms of improved academic performance. Lastly, all learners perceived the intervention to be relevant to their study.

Recommendations

The following recommendations were made based on the findings of the study:

1. Learners should be guided to be aware of their preferred learning styles so that they can decide on the best way to study.
2. Educators should make efforts to understand the learners, preferential learning styles so that they can prepare learning contents to suit the learners' needs.
3. Learners should be taught more with hands-on materials so that they can engage more in the classrooms.
4. Educators should introduce the use of video and audio aids to teach as these could motivate learners to study.

References

Ababio, O. Y. (2016). *New school chemistry for senior secondary school*. Africana First Publishers PLC.

Abel, M. & Medhat, A. (2016). The impact of the use of learning style strategy on some learning outcomes for students of education division. *Scientific Journal of Physical Education and Sport, 76*, 408-430

Abidoye, F. O. & Olorundare, A. S. (2020). The correlation between learning styles and biology learning performance of Nigerian students. *Jurnal Pendidikan Biologi Indonesia, JPBI, 6*(1), 107-112. https://doi.org/10.22219/jpbi.v6i

Aji, M. A. (2022). Research and chemistry education for national development. *Journal ScienceEducation, 23*(2), 1-4.

Almomani, J. A. (2019). Preferred cognitive learning patterns (vak) among secondary students admitted to King Saud University and its effect on their academic achievement in physics. *International Education Studies, 12*(6),108-119.

Bakri, R. A., Rahman, M. A., Jabu, B., & Jassruddin (2019). Exploring the impact of VAK learning style on teenager level language learners in Indonesia. *Journal of Language Teaching and Research, 10*(4), 807-814.

Barbe, W. B., Swassing, R. H., & Milone, M. N. (1979). Teaching through modality strengths: Concepts and practices. Columbus, Ohio: Zaner-Boser.

Bhagat, A, Vyas, R. & Singh T. (2015). Students awareness of learning styles and their perceptions to a mixed method approach for learning. *International Journal of Applied and Basic Medical Research, 5*(1), 58-65. Retrieved from https://ncbi.nlm.nih.gov

Chislett, V., & Chapman, A. (2005).VAK learning style self-assessment questionnaire. Retrieved from https://www.businessball.com

Engage Education (2023). VAK learning style: What are they and what do they mean? https://www.engage-education.com

Gholami, S. & Bagheri, M. S. (2013). Relationship between VAK learning styles and problem-solving styles regarding gender and students' fields of Study. *Journal of Language Teaching and Research, 4*(4), 700-706.

Ibrahim, M. S., Adamu, T. A., Ibrahim, A., Ismail, I. I., & Abubakar, M. A. (2017). Solving the problems of chemistry education in Nigeria: A panacea for national development. *American Journal of Heterocyclic Chemistry, 3*(4), 42-46.

Jack, G. U., Danjuma, E., & Abdul-Kadir, M. A. (2017). Assessment of conceptual difficulties in chemistry syllabus of the Nigerian science curriculum as perceived by high school college students. *American Journal ofEducational Research, 5*(7), 710-716.

Kouhan, N., Janatolmakan, M., Rezaei, M. & Khatony, A. (2021). Relationship between learning styles and academic performance among virtual nursing students: A cross-sectional study. Retrieved from www.hindawi.comhttps://doi.org/10.1155/2021/8543052

Mislina, A., & Hazmilah, H. (2017). Gender and faculty relation to VAK learning stylepreferences among technical students. Proceeding of mechanical engineering research day. Centre for Advanced Research on Energy, 1-2.

Moussa, N. (2014). *The importance of learning styles in education.* Retrieved from https://www.auburn.edu

Oladejo, A. I., Ademola, I. A., Ayanwale, M. A., & Tobih, D (2023). Concept difficulty in secondary school chemistry - an intra-play of gender, school location and school type. *Journal of Technology and Science Education, 13*(1), 255-275. https://doi.org/10.3926/jotse.1902

Reid, J. (1987). *Perceptual learning style preference questionnaire.* Retrieved from https://www.fyse2015.files.wordpress.com

Sreenidhi, S. K., & Tay, C. H. (2017). Styles of learning based on the research

Fernarld, Keller, Orton, Gillingham, Stillman, Montessori and Neil D. Fleming. *International Journal for Innovative Research in Multidisciplinary Field, 3*(4), 17-25.

Sumitha, P. & Prasadh, R. S. (2022). Learning styles of secondary school students. *Journal of Positive School Psycology, 6*(8), 9088-9099. Retrieved from http://journalppw.com

Takane, R., Pilcher, L. A., & Potgieter, M. (2020). Blended learning in a second year organic chemistry class: Students' perceptions and preferences of the learning support. *Chemistry Education Research and Practice, 21*(1), 24-36.

University of Wisconsin-Madison (2024). Learning styles: Perceiving and processing information. Retrieved from https://www.fyi.extension.wisc.edu

West African Examination Council, (2022). West African Senior School Certificate Examination Chief Examiner's Report.WAEC.

Vagias, W. M. (2006). "Likert-type scale response anchors. Clemson International Institute forTourism & Research Development, Department of Parks, Recreation and Tourism Management. Clemson University.

Worokwu, C. (2016). Perceived difficult topics in chemistry in senior secondary schools in River State, Nigeria. *Direct Research Journal of Social Sciences and Educational Studies, 3*(3), 81-89. https://doi.org/10.26765/DRJSSES017473429