JURNAL UPI

Assimilation: Indonesian Journal of Biology Education
ISSN 2621-7260 (Online)
Journal homepage: https://ejournal.upi.edu/index.php/asimilasi

Preservice biology teachers using chart-based instruction to improve students' achievement

Joy Abiola Onipede*[1], Blessing Aderibigbe Ariba[1], Abayomi Taiwo Ogunleye[2], Kabir Adekun Adelakun[3], Johnson Oluwasaanumi Olabode[4]

[1)]Centre for Sandwich Program, Lagos State University, Federal College of Education, Abeokuta Study Centre, Ogun State, Nigeria
[2)]Biology Department, Federal College of Education Abeokuta-Ibadan Rd, Abeokuta 110121, Ogun State, Nigeria
[3)]African Climate Environment Centre-Future African Savannas (AFAS)
[4)]Federal Science and Technical College, Ilerin 233285, Osun, Nigeria
*Corresponding author: jaonipede@uesc.br

OPEN ACCESS

ARTICLE HISTORY

Received: 24 December 2024
First Revised: 15 March 2025
Accepted: 30 March 2025
First Available Online: 30 March 2025
Publication Date: 30 March 2025

KEYWORDS

Biology student achievement
Chart instruction
Preservice teacher
Visual aids

ABSTRACT

The ability to analyse and interpret data or diagrams is an important part of science process skills. To support the achievement of these learning objectives, teacher education should teach preservice biology teachers (PBTs) with the use of charts and graphs. This research examines the application of charts by PBTs in the instruction of biology and its impact on students' achievement. A mix methods research design was employed to evaluate the utilization of charts by PBTs. Data was analysed using descriptive statistics to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the hypotheses. Findings revealed that 51.8% of PBTs frequently utilize charts in biology classroom. They stated that chart usage makes them confident to teach biology concepts. The result further revealed a statistically significant effect of charts on students' achievement in biology, with $F(1,235) = 146.286$ and $p < 0.05$. Meanwhile, results showed that there was no significant main effect of gender on students' achievement in biology using chart-based instruction., $F(1,235) = 0.058$, $p > 0.05$. Further, the result revealed that there was no interaction effect of treatment (chart-based instruction) and gender on students' academic achievement in biology ($F(1,235) = 0.363$, $p > 0.05$). This study had provided insights for institutions in teacher training programs on the importance of incorporating visual aid training for the pre-service teachers, as it had proven to increase their teaching confidence, effectiveness, and students' achievement in biology.

INTRODUCTION

Teacher education constitutes a systematically organized educational framework specifically devised for the training, and development of qualified educators across all domains of the academic spectrum (Umeora & Jacob, 2020). This education is directed towards individuals aspiring to pursue and build careers within the teaching profession (Ogunode & Agwor, 2020). The primary function of teacher education programs is to "equip educators to effectively operate within primary and secondary educational institutions while fostering their evolution into reflective and adept practitioners capable of delivering high-quality education to learners" (Buabeng et al., 2020). The institutions that the Nigerian government gives recognition to provide teacher education are as follows: Colleges of Education; Faculty of Education; Institutes of Education and National Teachers Institute (Kingsley et al., 2024). The Federal College of Education, located in Abeokuta, Ogun State, Nigeria, represents one of the educational institutions entrusted with the formidable responsibility of producing teachers for both primary and secondary educational settings.

The curriculum of teacher education programs integrates instructional methodologies, robust pedagogical theories, and essential professional competencies (Kingsley et al., 2024). Pre-service teachers participate in teacher preparation strategies (TPS), which may encompass both undergraduate studies focused on TPACK (Baran et al., 2019). TPS provides pre-service teachers with the essential knowledge, skills, and competencies required to develop into effective educators (Diery et al., 2021), ultimately benefiting not only the students but also society as a whole. The preparation for the teaching profession must fullfill the objectives inherent in the educational process while concurrently addressing the challenges confronting current teachers' education initiatives.

In addition to foundational academic, it is crucial to offer professional training that will furnish them with a diverse array of knowledge and skills needed during their teaching career. It is important to recognize that the education these students receive in teacher preparation programs significantly contributes to their readiness for in-service teaching responsibilities (Rif'attullah & Ciptaningrum, 2024). To achieve these aims, future teachers are granted access to the real-world teaching situations, through teacher preparation programs such as; field experiences, student teaching, or internships, where pre-service teachers gain hands-on experience working in real classroom settings under the supervision of experienced educators (Heafner et al., 2014). These field experiences allow PBT to apply theoretical knowledge in practical contexts and develop teaching skills. In this digital era, PBTs must master teaching skills so that students have the functional ability to face the era. At the secondary education stage, students must be taught how to read data scientifically (Gould, 2021)

PBT can learn how to use various software tools or online platforms to design visually appealing and informative charts. Despite the growing prevalence of technology, the use of charts remains a crucial part of instruction explored by the pre-service teachers to illustrate biological concepts (Enzingmüller & Prechtl, 2021; Mayes et al., 2020). The ability to analyze and interpret data is an important part of science process skills and the science education curriculum (Ergül, 2018). As the pedagogical process transitions towards a framework centered on digital methodologies, one might predict that conventional instructional techniques, such as the utilization of charts and diagrams, would diminish in significance. Bowen & Roth (2005) explained that preservice teachers need more experience in engaging in data and graph interpretation practices originating in activities that provide the degree of variation in and complexity of data present in realistic investigations. It is crucial to investigate the impact of chart data utilization on students' academic performance in biology, as it is important to comprehend how conventional tools such as diagrams persist in shaping educational outcomes in the digital age. Consequently, this research was conducted to assess the effect of chart usage on the study of Biology in secondary schools.

DOI: https://doi.org/10.17509/aijbe.v8i1.78439
e-ISSN 2621-7260

Literature Review

This study is anchored on the cognitive theory of multimedia learning of (Mayer, 2005), which posited that people learn more deeply from words and pictures than from words alone. It sourced knowledge from Paivio's Dual coding theory (1990), Sweller's Cognitive load theory (1994), and Bruner's Constructivist theory (1960) that was made popular by Mayer and other cognitive researchers. According to Mayer (2005), the integration phase represents the most critical aspect of visual aids learning, as it necessitates the establishment of connections between word-based and picture-based information. Research conducted by Mayer (2005) has demonstrated that significant learning occurs through the learner's efforts to synthesize verbal and visual data (such as charts or images). The central premise of the cognitive theory of multimedia learning is that multimedia significantly enhances the ways in which the human cognitive system acquires and processes information. Consequently, learners are likely to experience improved learning outcomes, achievement, and performance when visual aids like images and charts are utilized alongside textual content to aid comprehension. The cognitive multimedia theory advocates that the association of verbal and visual models fosters mutual reinforcement and support between the two modalities. Furthermore, the theory asserts that for substantive learning to materialize, learner must engage in three cognitive processes: selection, organization, and integration of the received information, which comprises both textual and visual elements. Consequently, the learner is able to comprehend effectively due to the concurrent processing of various models. Integration occurs when an educator delivers the material through both verbal explanations and visual representations. Therefore, textual and visual information mutually enhance the learning experience in the field of biology. Meaningful learning signifies the students' capacity to grasp the concepts presented and to translate that comprehension into superior performance in both formative and summative assessments.

Visual aids are defined as materials or demonstrations employed during oral presentations to augment or amplify verbal communications. These aids promote learning by appealing to the visual senses of learners (Hamad, 2023). Adewale (2024) explained visual aids as any materials conveyed to an audience in a visually perceivable format to complement the auditory information they receive. Guney (2019) found out that the utilization of visual educational tools contributes positively to the enhancement of classroom instruction. As a result, visual aids refer to any instructional tools that engage the visual sense, employed by educators to promote meaningful learning experiences. This category includes tangible objects (realia), models, specimens, as well as pictorial representations or charts. Visual aids can be classified into two categories: projected and non-projected.

Mahmood et al. (2024) explain that projected visual aids include images shown on a screen through specific devices such as filmstrip projectors, slide projectors, overhead projectors, or television/VCR systems. Projected media materials are employed in pedagogical practices to enhance interaction between educators and students while providing a more scientific framework for systematic instructional design. Conversely, visual aids are instructional resources that do not necessitate any form of projection for effective utilization (Mohamed & Hamza, 2011). Non-projected visual arouses the interest and gain the attentions of the learners in order to aid the teachers' explanations and make learning of subject matter understandable (Kadir, 2020). These resources are readily accessible and can be sourced from the local environment or created by educators. Kadir (2020) argues that a key benefit of projected visual aids compared to non-visual aids is their ability to display any type of material that is written, illustrated, or printed. He further noted that this modality of projection can be effectively employed in environments with moderate illumination, thereby facilitating efficient note-taking and promoting teacher-student engagement.

A quintessential example of a non-projected visual aid is a chart. In the context of biology education, charts function as potent visual aids that enhance comprehension, engagement, and retention of intricate biological concepts. Charts are defined as graphic materials composed of

DOI: https://doi.org/10.17509/aijbe.v8i1.78439
e-ISSN 2621-7260

one or more forms of visuals, including images, illustrations, diagrams, etc., along with textual components designed to provide a clear visual synopsis of an essential process, concept, or set of interrelationships (Divecha et al., 2023). Charts are frequently utilized to illustrate the hierarchical classification of living organisms, encompassing domains, kingdoms, phyla, classes, orders, families, genera, and species. These charts, referred to as taxonomic charts or phylogenetic trees, visually delineate the evolutionary connections among various groups of organisms. Charts or diagrams are used to support the construction of scientific explanations (Tang, 2023). Reading data and interpreting charts are important skills in scientific data analysis. The ability to read the presentation of data in charts evidences the development of critical thinking (Romero Ariza et al., 2024). The primary benefit of charts is that they afford individuals the opportunity to visualize concepts or ideas that would otherwise be challenging to grasp if conveyed solely through verbal or written communication (Divecha et al., 2023).

Research Question

This study first trained PBTs to use the charts and continued with their application in biology classes, so the research question is as follows:
RQ1: To what degree do pre-service teachers incorporate charts in their Biology instruction?
RQ2: What are the factors that affect the use of charts by pre-service teachers?
RQ3: What is the effect of chart usage on improving students' achievement in Biology?

Hypotheses

To determine the effectiveness of using charts in biology class, the researcher proposed 3 hypotheses, as follows:
H10: There is no significant main effect of treatment (charts and conventional method) on students' achievement in Biology.
H20: There is no significant effect of gender on students' achievement in Biology.
H30: There is no considerable interactive effect of treatment (charts and conventional method) and gender on students' achievement in Biology.

METHODS

The mix methods design was proposed in this study: descriptive survey research type and a pre-test post-test quasi-experimental research design. The first phase, PBTs underwent training program for one week before they were certified good enough to teach the students. The researcher prepared uniform lesson notes for the teachers based on the selected topics in biology using charts. In this phase, the data taken to answer research question using "Perceived Influence of Using Charts on Biology Students' Achievement". The descriptive research was adopted to assess the perceived influence of charts from the pre-service Biology teachers. The questionnaire was divided into two sections: Section A gathered demographic information about the respondents, including gender and age, while Section B explored the extent of chart usage in Biology instruction, the effects of charts on teaching and learning, and the challenges that impede effective chart utilization. This section included 10 items rated on a 4-point Likert-type scale ranging from strongly agree to strongly disagree. A pilot test of the instrument was conducted with 12 pre-service teachers who were not part of the main sample but belonged to the same population. The reliability of the instrument was established using the Cronbach Alpha method, yielding a reliability coefficient of 0.78, indicating that the instrument is reliable for use.

The second phase of the research utilized an experimental non-equivalent control group design to assess the impact of chart usage on students' achievement in Biology. The Biology

DOI: https://doi.org/10.17509/aijbe.v8i1.78439
e-ISSN 2621-7260

Achievement Test comprised 20 multiple-choice questions related to the concepts taught through charts. Validation of the instrument was performed by two experts in science education specializing in Biology and two experts in test development, who assessed its relevance and coverage of the curriculum objectives. The Kuder-Richardson 21 (K-R21) method was utilized to determine the reliability of the test. The computed value was determined to be 0.84. Data from phase two were examined through, analysis of covariance (ANCOVA) to evaluate the hypotheses. All hypotheses were assessed at a significance level of 0.05.

The study population consists of all pre-service teachers at the Federal College of Education in Abeokuta who are teaching Biology, as well as Biology students in secondary schools located within Abeokuta. A convenient sampling method was employed to select 83 pre-service biology students engaged in teaching practice at both public and private secondary schools in the area. This research was conducted in biology learning related to socio-scientific issues as the population of interest due to the fact that they were new to this subject Biology as this will help neutralize the effect of the interfering variable such as the influence of previous knowledge of Biology on the topic. The experiment in phase two was restricted to six (6) secondary schools in the Abeokuta which were selected using stratified random sampling technique constituting 240 students' population. Three pre-service teachers, each from the six selected secondary schools, taught the students.

RESULTS AND DISCUSSION

Gender analysis of the respondents revealed that 54 of the biology pre-service teachers were female representing 65.1% while males were 29 representing 34.9% of the respondents. By implication, females were more in number. Also, the result further shows respondents' distribution based on age, 47% of the respondents are between the age of 19-22 years, and 36.1% fall between the ages of 17-19 years. Conversely, 16.9% of the participants are over the age of 23. Patahuddin & Lowrie (2019) stated that there is no difference between the understanding of the use of charts/graphics in learning between men and women. The focus on teacher education should provide a comprehensive understanding for PBT to master how to read and create diagrams in biology learning.

Table 1. Socio-demographic characteristics of the respondents

Variables	Frequency	Percentage (%)
Gender of the Respondents		
Male	29	34.9
Female	54	65.1
Age of the Respondents		
17-19 years	30	36.1
19-22 years	39	47.0
23 years and above	14	16.9

RQ1: To what degree do pre-service teachers incorporate charts in their Biology instruction?

The findings presented in Table 2 illustrate the frequency with which pre-service Biology teachers incorporate charts into their Biology instruction in secondary schools. The data indicates that a significant portion (51.8%) of the pre-service teachers frequently utilize charts, while 33.7% reported that they consistently employ charts, and 14.5% stated that they occasionally use charts in their Biology teaching. This suggests that a majority of the respondents regularly integrate charts into their instructional practices. Furthermore, regarding the types of charts predominantly used, the results show that 42.2% utilize diagrams, 36.1% employ bar or pie charts, and 21.7% use tables during their teaching sessions. This indicates that diagrams are the preferred method for

DOI: https://doi.org/10.17509/aijbe.v8i1.78439
e-ISSN 2621-7260

conveying biological concepts among the respondents. Additionally, 56.6% of the participants believe that the use of charts in Biology instruction is highly effective. Notably, the same percentage (56.6%) expressed confidence in their ability to create and effectively use charts in their Biology teaching, suggesting that the respondents feel assured in their capacity to incorporate charts into their instructional methods. From these observations, it can be concluded that pre-service Biology teachers, to a considerable degree, utilize charts in their teaching practices.

Table 2. Extent of pre-service teachers use of charts.

Extent of use of charts to teach Biology	Indicator	Freq.	%
How often do you use charts as teaching aid in Biology lessons?	Rarely	-	-
	Sometimes	12	14.5
	Often	43	51.8
	Always	28	33.7
What types of charts do you commonly use in your biology lessons?	Diagram	35	42.2
	Pie/Bar chart	30	36.1
	Tables	18	21.7
How effective are you in using charts in teaching biology?	Not Effective	19	22.9
	Effective	17	11.5
	Very Effective	47	56.6
I feel confident in my ability to create and utilize charts effectively in biology teaching:	Always		
	Often	47	56.6
	Sometimes	34	41.0
	Never	2	2.4

RQ2: What are the factors that affect the use of charts by pre-service teachers?

The subsequent results (Figure 1) outline the factors that influenced pre-service teachers' decisions regarding the use of charts in Biology instruction. A notable 71.1% indicated that the availability of resources for chart creation impacted their usage, while 72.3% stated that student engagement played a crucial role in determining the use of charts. Additionally, the majority identified personal preference as the most significant factor influencing their decision to use charts in teaching Biology. Conversely, curriculum requirements were noted as the least influential factor in this context. This indicates that availability of resources, students' engagement, and personal preference are the primary factors motivating PBTs to incorporate charts into their teaching practices.

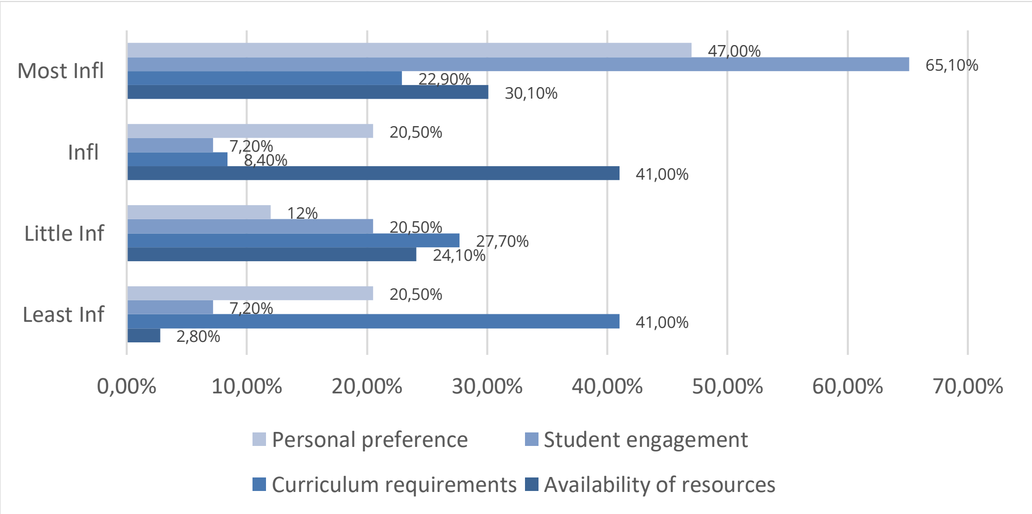

Figure 1. Factors that influence the choice of charts among the pre-service teachers

DOI: https://doi.org/10.17509/aijbe.v8i1.78439
e-ISSN 2621-7260

RQ3: What is the effect of chart usage on the teaching and learning of Biology?

The findings presented in Table 3 illustrate the impact of utilizing charts in the instruction and comprehension of biology. The data indicates that respondents expressed agreement with all items, scoring 3.51, 3.00, 3.45, 3.12, 3.23, and 3.42, respectively, all of which exceed the established criterion mean value. This suggests that the respondents believe that employing charts in biology instruction enhances teaching effectiveness, provides greater control over the educational process, supports engagement, and mitigates monotony during lessons. Furthermore, the integration of charts facilitates the teaching and learning of biology, aiding in the attainment of specified educational objectives. The incorporation of charts in instructional practices enhances clarity and diversifies the teaching approach. Consequently, it can be concluded that the use of charts significantly influences the teaching and learning of biology in secondary education settings.

Table 3. Effect of the use of charts in teaching and learning biology

	Items	SA	A	D	SD	Mean	Remarks
1	Teaching biology using charts enhances effective teaching	55 (66.3%)	21 (25.3%)	1 (1.2%)	6 (7.2%)	3.51	Accepted
2	Teaching using charts as instructional aids gives me total control over my teaching	17 (20.5%)	55 (66.3%)	5 (6%)	6 (7.2%)	3.00	Accepted
3	Charts support and reduce boredom while teaching	40 (48.2%)	40 (48.2%)	3 (3.6%)		3.45	Accepted
4	Teaching and learning biology become much easier with charts	21 (25.3%)	51 (61.4%)	11 (13.3%)		3.12	Accepted
5	Integrating charts as aid assists me in achieving my teaching objectives	28 (33.7%)	40 (48.2%)	13 (15.7%)	2 (2.4%)	3.23	Accepted
6	The use of charts during teaching increases clarity and makes my teaching different	38 (45.8%)	36 (43.4%)	7 (8.4%)	2 (2.4%)	3.42	Accepted
	Weighted Mean = 3.29						

Next is the analysis to determine the effect of using charts in biology class on students' biological knowledge achievement. The results of the covariance test in the control and experimental classes are presented in Table 4. The results presented in Table 4 summarize the Analysis of Covariance (ANCOVA) conducted on students' post-test achievement scores in biology, categorized by treatment (charts and control) and gender. The analysis indicates that, after controlling for the covariance (pre-test score in BAT), the treatment had a statistically significant effect on students' achievement in biology, with $F(1,235) = 146.286$ and $p < 0.05$. As a result, the null hypothesis, which posited that there was no significant main effect of treatment on students' achievement in biology, was rejected. Additionally, the findings revealed a Partial Eta Square of .384, suggesting that 38.4% of the variance in students' achievement in biology can be attributed to the treatment. This indicates that the use of charts is both potent and effective in improving students' performance in biology.

DOI: https://doi.org/10.17509/aijbe.v8i1.78439
e-ISSN 2621-7260

Table 4. Summary of analysis of covariance (ANCOVA) of students' achievement in biology by treatment (chart and control) and gender

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3872.426a	4	968.107	37.629	.000	.390
Intercept	13145.176	1	13145.176	510.930	.000	.685
PRETEST	83.231	1	83.231	3.235	.073	.014
Treatment	3763.644	1	3763.644	146.286	.000	.384
Gender	1.500	1	1.500	.058	.809	.000
Treatment * Gender	9.327	1	9.327	.363	.548	.002
Error	6046.070	235	25.728			
Total	203777.000	240				
Corrected Total	9918.496	239				

a. R Squared = .390 (Adjusted R Squared = .380)

To identify which of the two treatment groups exhibited significant differences, a Sidak Post-hoc analysis was conducted, with the results detailed in Tables 5 and 6.

Table 5. Estimated marginal means of students' achievement in biology by treatments

Experimental Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Charts Group	31.080a	.395	30.301	31.858
Lecture Method	21.944a	.627	20.709	23.179

a. Covariates appearing in the model are evaluated at the following values: Pre-Test = 14.33.

Table 6. Pairwise Comparison of students' achievement in biology by treatment

(I) Experimental Group	(J) Experimental Group	Mean Difference (I-J)	Std. Error	Sig.b	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
Charts Group	Lecture Method	9.136*	.755	.000	7.648	10.624
Lecture Method	Charts Group	-9.136*	.755	.000	-10.624	-7.648

Based on estimated marginal means
*. The mean difference is significant at the .05 level.
b. Adjustment for multiple comparisons: Sidak.

Result in Table 5 revealed that experimental Group (Charts group) has the highest mean score of (=31.080). In contrast, the control group has the lowest mean score of (=21.944). The result presented in Table 6 confirmed that the difference between the treatment group (charts group) and the control group was statistically significant. Qasserras (2024) also found out that students taught with visual devices (charts and real objects) acquired better knowledge, and improved comprehension skills. Jeptoo & Mogeni (2024) reported improved performance in the students taught biology with visual aids. They opined that the application of relevant visual devices (charts) during teaching-learning process give better results than mere talking and writing. The findings supported by the study of Abdullah & Abbas (2022) whose study revealed that there was significant difference between the performances of students in term of problem solving taught with graphic organizer. The use of charts in biology learning is a form of teacher support to achieve their learning goals. Teacher support has a positive impact on student achievement (Tao et al., 2022).

Result in Table 4 shows that there is no significant main effect of Gender on students' Achievement in biology, F (1,235) = 0.058, p> 0.05. Therefore, the stated null hypothesis that there is no significant main effect of Gender on students' Achievement in biology was not rejected (H20). Result presented in Table 4 revealed that there was no interaction effect of treatment and gender on students' academic achievement in biology (F (1,235) = 0.363, p >0.05, The null hypothesis was therefore not rejected (H30). The finding is contrary to that of Woldemariam et al. (2024) and Adewale (2024) who noted that there is no significant gender difference in students' performance when taught using visual aids. Essentially, these findings are consistent with those of Woldemariam et al. (2024), which confirmed that visual devices effectively capture students' attention, regardless of gender. Furthermore, the research by Ibe & Abamuche (2019) demonstrated that audio-visual aids positively influenced student performance, with no significant differences noted between male and female students taught using these aids. This suggests that gender does not play a significant role in the academic success of students learning biology through charts.

CONCLUSION

The findings of this study indicate that pre-service biology teachers utilize charts to varying extents in their instruction at the secondary school level. The use of charts fosters greater student engagement and creativity, reduces boredom during lessons, and contributes to improved academic achievement in biology. Moreover, charts enhance the clarity of instruction and help distinguish teaching approaches, thereby supporting more effective learning experiences. The study also highlights that chart-based instruction gives pre-service teachers a stronger sense of control during lessons, which can positively impact classroom management and instructional quality. These findings provide valuable insights for teacher training institutions, emphasizing the importance of incorporating visual aid training into pre-service teacher education, as it has been shown to boost both teaching confidence and effectiveness.

REFERENCES

Abdullah, N. A., & Abbas, N. H. (2022). Teachers' exploration using graphic organizer for problem solving in primary mathematics. *Hiroshima Journal of Mathematics Education*, *15*(1), 19–33.

Adewale, S. (2024). Utilisation of audiovisual aids in the teaching and learning of business studies in secondary schools in Lagos State, Nigeria. *Jurnal Bidang Pendidikan Dasar*, *8*(2), 175–184. https://doi.org/10.21067/jbpd.v8i2.10167

Baran, E., Canbazoglu Bilici, S., Albayrak Sari, A., & Tondeur, J. (2019). Investigating the impact of teacher education strategies on preservice teachers' TPACK. *British Journal of Educational Technology*, *50*(1), 357–370. https://doi.org/10.1111/bjet.12565

Bowen, G. M., & Roth, W.-M. (2005). Data and graph interpretation practices among preservice science teachers. *Journal of Research in Science Teaching*, *42*(10), 1063–1088. https://doi.org/10.1002/tea.20086

Buabeng, I., Ntow, F. D., & Otami, C. D. (2020). Teacher education in Ghana: Policies and practices. *Journal of Curriculum and Teaching*, *9*(1), 86. https://doi.org/10.5430/jct.v9n1p86

Diery, A., Knogler, M., & Seidel, T. (2021). Supporting evidence-based practice through teacher education: A profile analysis of teacher educators' perceived challenges and possible solutions. *International Journal of Educational Research Open*, *2*. https://doi.org/10.1016/j.ijedro.2021.100056

Divecha, C., Tullu, M., & Karande, S. (2023). Utilizing tables, figures, charts and graphs to enhance the readability of a research paper. *Journal of Postgraduate Medicine*, *69*(3), 125–131. https://doi.org/10.4103/jpgm.jpgm_387_23

Enzingmüller, C., & Prechtl, H. (2021). Constructing graphs in biology class: Secondary biology teachers' beliefs, motivation, and self-reported practices. *International Journal of Science and Mathematics Education*, *19*(1), 1–19. https://doi.org/10.1007/s10763-019-09975-2

Ergül, N. R. (2018). Pre-service science teachers' construction and interpretation of graphs. *Universal Journal of Educational Research*, *6*(1), 139–144. https://doi.org/10.13189/ujer.2018.060113

Gould, R. (2021). Toward data-scientific thinking. *Teaching Statistics*, *43*(S1). https://doi.org/10.1111/test.12267

Guney, Z. (2019). Visual literacy and visualization in instructional design and technology for learning environments. *European Journal of Contemporary Education*, *8*(1). https://doi.org/10.13187/ejced.2019.1.103

Hamad, J. I. (2023). The impacts of visual aids in promoting the learning processes in schools in Pakistan. *African Journal of Education and Practice*, *9*(1), 51–60. https://doi.org/10.47604/ajep.1912

Heafner, T. L., Lipscomb, G. B., & Fitchett, P. G. (2014). Instructional practices of elementary social studies teachers in North and South Carolina. *The Journal of Social Studies Research*, *38*(1), 15–31. https://doi.org/10.1016/j.jssr.2013.12.002

Ibe, E., & Abamuche, J. (2019). Effects of audiovisual technological aids on students' achievement and interest in secondary school biology in Nigeria. *Heliyon*, *5*(6). https://doi.org/10.1016/j.heliyon.2019.e01812

Jeptoo, N., & Mogeni, J. M. (2024). Role of volunteerism as a parental involvement strategy in the achievement of core competencies among learners in public primary schools in nandi county, Kenya. *Research Journal of Education, Teaching and Curriculum Studies*, *2*(1), 25–34. https://doi.org/10.58721/rjetcs.v2i1.599

Kadir, A. N. J. (2020). Instructional media and management of elementary schools' education in kwara state, Nigeria. *Indonesian Journal of Elementary Teachers Education*, *1*(1). https://doi.org/10.25134/ijete.v1i1.2678

Kingsley, E., Zulaihatu, S., & Ewhe, P. O. (2024). Teachers education in Nigeria: Problems and prospects. *American Journal of Education and Evaluation Studies*, *1*(2), 9–15.

Mahmood, I., Bukhari, S. K. U. S., & Bahoo, R. (2024). Effectiveness of visual aids in teaching of english at secondary school level. *Pakistan Journal of Humanities and Social Sciences*, *12*(2). https://doi.org/10.52131/pjhss.2024.v12i2.2200

Mayer, R. E. (2005). Cognitive theory of multimedia learning. In *The Cambridge Handbook of Multimedia Learning* (pp. 31–48). Cambridge University Press. https://doi.org/10.1017/CBO9780511816819.004

Mayes, R., Long, T., Huffling, L., Reedy, A., & Williamson, B. (2020). Undergraduate quantitative biology impact on biology preservice teachers. *Bulletin of Mathematical Biology*, *82*(6), 63. https://doi.org/10.1007/s11538-020-00740-z

Mohamed, B., & Hamza, N. (2011). *Inclusion of pupils with special education needs in Sudan: teachers' perceptions of their competence and their perceived training needs* [Doctoral Thesis]. University of London Institute of Education.

Ogunode, N. J., & Agwor, N. O. J. (2020). Administration teacher education in Nigeria: Problem and suggestion. *Journal of Applied and Theoretical Social Sciences*, *2*(4), 29–41. https://doi.org/10.37241/jatss.2020.17

Patahuddin, S. M., & Lowrie, T. (2019). Examining teachers' knowledge of line graph task: A case of travel task. *International Journal of Science and Mathematics Education*, *17*(4), 781–800. https://doi.org/10.1007/s10763-018-9893-z

Qasserras, L. (2024). THE role of visual learning aids across diverse learning styles in high school education. *European Journal of Applied Linguistics Studies*, *7*(2). https://doi.org/10.46827/ejals.v7i2.550

Rif'attullah, M., & Ciptaningrum, D. S. (2024). Exploring pre-service teacher professional learning on their preparedness for teaching practicum. *Formosa Journal of Sustainable Research*, *3*(8), 1779–1798. https://doi.org/https://doi.org/10.55927/fjsr.v3i8.10969

Romero Ariza, M., Quesada Armenteros, A., & Estepa Castro, A. (2024). Promoting critical thinking through mathematics and science teacher education: the case of argumentation and graphs interpretation about climate change. *European Journal of Teacher Education*, *47*(1), 41–59. https://doi.org/10.1080/02619768.2021.1961736

Tang, K. (2023). The characteristics of diagrams in scientific explanations: Multimodal integration of written and visual modes of representation in junior high school textbooks. *Science Education*, *107*(3), 741–772. https://doi.org/10.1002/sce.21787

Tao, Y., Meng, Y., Gao, Z., & Yang, X. (2022). Perceived teacher support, student engagement, and academic achievement: A meta-analysis. *Educational Psychology*, *42*(4), 401–420. https://doi.org/10.1080/01443410.2022.2033168

Umeora, As. M., & Jacob, O. N. (2020). Teacher education in Nigeria: problem, issues and suggestion. *International Journal on Integrated Education*, *3*(11), 108–113. https://doi.org/10.31149/ijie.v3i11.843

Woldemariam, D. Y., Ayele, H. S., Kedanemariam, D. A., Mengistie, S. M., & Beyene, B. B. (2024). Effects of technology-assisted chemistry instruction on students' achievement, attitude, and retention capacity: A systematic review. *Education and Information Technologies*, *29*(11), 13763–13785. https://doi.org/10.1007/s10639-023-12411-2

Acknowledgment

We express our sincere appreciation to the school authorities for granting us the permission to conduct this research in their institutions. We also extend our appreciation to all the pre-service teachers and students who took part in the research and offered invaluable supports

Authors' Note

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

How to Cite this Article

Onipede, J, A., Ariba, B, A., Ogunleye, A, T., Adelakun, K, A., & Olabode, J, O. (2025). Preservice biology teachers using chart-based instruction to improve students' achievement. *Assimilation: Indonesian Journal of Biology Education, 8*(1), 17-28. https://doi.org/10.17509/aijbe.v8i1.78439