



## Impacts of the Performance Arts Enhanced Instructional Model on Secondary School Students' Conceptual Understanding of Ecology and Attitudes Towards Science

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### Abstract

The integration of the arts and sciences is a research agenda that is informing science teachers' pedagogical practices. The study therefore designed drama, dance and music into a single instructional paradigm tagged "the Performance Arts Enhanced Instructional Model (PAEIM)" which was implemented during the learning of ecology concepts. This quasi-experimental research design study that incorporated gender and mental ability as moderator variables was conducted with 211 secondary school biology students. The Ecology Concept Test (ECT) and the modified Attitudes Towards Science Inventory (mATSI) were used to collect data on students' conceptual understanding of ecology concepts and attitudes towards biology respectively. Empirical findings pinned the PAEIM as an effective instructional model that significantly improved students' conceptual understanding of ecology and their general attitudes towards science. Further findings revealed significant interactions of treatment and gender, treatment and mental ability, and treatment, gender and mental ability on students' attitudes towards science respectively. The implications of these findings were extensively discussed while the researchers called for the pedagogical training of science teachers to implement the PAEIM across multiple instructional contexts.

**Keywords:** Performance Arts, Instructional Model, Ecology Learning, Science Attitudes

### Introduction

Innovations and emerging trends in science teaching and learning have highlighted the need for integrating Arts with Science, Technology, Engineering and Mathematics (STEM) to develop a new curriculum paradigm tagged STEAM owing to the role interdisciplinary instructional approach plays in enhancing students' conceptual understanding of science concepts as they engage in an artistic line of thoughts and experimentation with scientific data (Braund & Reiss, 2019; Colucci-Gray, Burnard, Cooke, Gray & Trowsdale, 2017; Harris & de Bruin, 2018). The learning of science concepts through drama makes students view science as a social and human enterprise that motivates them to study science (Peleg & Baram-Tsabari, 2016). While previous studies have focused on leveraging science drama as a teaching methodology, a new perspective is focusing on the development of instructional models that embed the performance arts (Kolovou & Kim, 2020; Oladipo & Akhigbe, 2022).

Part of the goals of biology education is to enhance students' conceptual understanding of biology concepts, facilitate the application of biology concepts, principles, theories and laws in everyday life and to develop functional and reasonable scientific attitudes. Nonetheless, researchers have reported that gaining mastery of biology concepts can be quite difficult for

students with specifics to abstract biology concepts (Oladipo & Ihemedu, 2016; Oladipo, Osokoya & Udeani, 2019). For instance, ecology, a fundamental concept in the biology curriculum is perceived to be very difficult and dreaded among Nigerian students. This problem escalates with high failure rates recorded annually in past external examination questions on ecology (Agbogorom & Oyovwi, 2015; Egerue, 2019; Etobro & Fabinu, 2017). This abysmally poor performance is induced by students' inability to comprehend or represent ecology concepts. Decades of research have also shown that students and even teachers maintain high misconceptions that are at variance with scientifically acceptable knowledge in ecology and ecosystems concepts (Adeniyi, 1985; Beals, Krall & Wymer, 2012; Chabalengula, Sanders & Mumba, 2012; Eromosele & Ekholuenetale, 2016; Yorek, Ugulu, Sahin & Dogan, 2010). In other to address these anomalies, Yucel and Ozkan (2015) called for an instructional design that has the potential to enhance students' understanding of the ecosystem, biodiversity, and environmental issues. Tools such as visual representations delivered through an integrative learning approach show some prospect in this regard since learning with external representations help students create mental models of abstract concepts and phenomenon (Ainsworth et al., 2016; Tsui & Treagust, 2013).

Scientific ideas are inspiring to students whose senses have been trained to appreciate the aesthetics and beauty of science. The teaching and learning of science concepts should provide students with meaningful experiences that enable them to connect what they learn to real-world contexts (Abed, 2016). Verelas et al., (2010) pointed out that scientific drama makes learning exciting, fun and interactive for the students which in the long run improves their attitude towards science. Abed's (2016) quasi-experimental study which investigated the effect of drama-based science teaching on 7<sup>th</sup> grade students' conceptual understanding of scientific concepts and attitudes towards science reported a statistically significant impact of this instructional paradigm on students' conceptual understanding of scientific concepts and attitudes towards science respectively in favour of the experimental group. This study demonstrated that the embedment of performance arts and specifically scientific drama into biology instruction is promising in enhancing students' cognitive engagements and attitudes towards science.

Gender and mental ability functions have been pinned to influence students' learning with multimodal external representations. Gender refers to socially constructed roles, duties, behaviours and mannerism that is ascribed to the human sexes. It is the psychological experience of being a male or female (Udousoro, 2011). On the other hand, mental ability refers to students' capabilities to perform higher mental processes of reasoning, remembering, understanding and finding solutions to problems. It is the ability to learn and retain knowledge without much assistance or instructional scaffolding from another individual (Akhigbe & Ogufere, 2020). Previous studies suggest that learning with multimodal external representations bridges the achievement gap in the performance of low, medium and high ability learners. In addition, past studies have shown that gender plays a significant role in shaping secondary school students' attitudes towards science (Hong & Lin, 2011; Wan & Lee, 2017). Hence, researchers are exploring how these variables moderate students' learning outcomes in biology (Chen, Wang, Dede & Grotzer, 2017; Akhigbe & Adeyemi, 2020; Akhigbe & Ogufere, 2020; Oladipo & Akhigbe, 2022).

The performance arts embedded instruction comes to light in the multimodal representation of ecology concepts through drama, dance and music.

Performance arts is an improvised or scripted instructional activity that integrates drama, dance and music in a single instructional paradigm (Oladipo & Akhigbe, 2022). Although previous studies have established that the incorporation of drama into science instruction is promising for improving students' understanding of science and ecology concepts, motivation and attitudes towards science (Abed, 2016; Cokadar & Yilmaz, 2010; Duin, 2019; Hendrix, Eick, & Shannon, 2012; Maharaj-Sharma, 2017; Saka, Ebenezer, Cakir & Saka, 2016), regardless there is a dearth of studies where drama, dance and music were blended into a single instructional paradigm (Oladipo & Akhigbe, 2022). The pedagogical impact highlighting the place of music and dance in science instruction is yet to be fully explored in extant literature. In a drive to bridge this knowledge gap, Oladipo and Akhigbe (2022) developed the Performance Arts Enhanced Instructional Model (PAEIM). The recent study builds on this previous work by implementing the PAEIM instructional model in the teaching and learning of ecology concepts and assessing its pedagogical impact on secondary school students' conceptual understanding of ecology concepts and attitudes towards science with the inclusion of gender and mental ability functions as moderator variables.

### **The Performance Arts Enhanced Instructional Model**

The PAEIM (see Figure 1) is an instructional model that incorporates drama, dance and music into a single instructional paradigm (Oladipo & Akhigbe, 2022). This instructional model is grounded on the social constructivists' perspective of learning that theorizes knowledge construction as a product of social interaction mediated by activities and cultural tools such as language (Marsh & Ketterer, 2005; Prawat & Floden, 1994; Vygotsky, 1978). It also rests on the premise that the collaborative dialogue replete with the performance arts provides a rich context for developing a shared understanding and common ground for communication and interactions that enable students to learn meaningfully (Oladipo & Akhigbe, 2022). A visual representation of the PAEIM model as shown in Figure 1 below highlights the instructional steps taken in the course of implementing this model in an authentic instructional context.

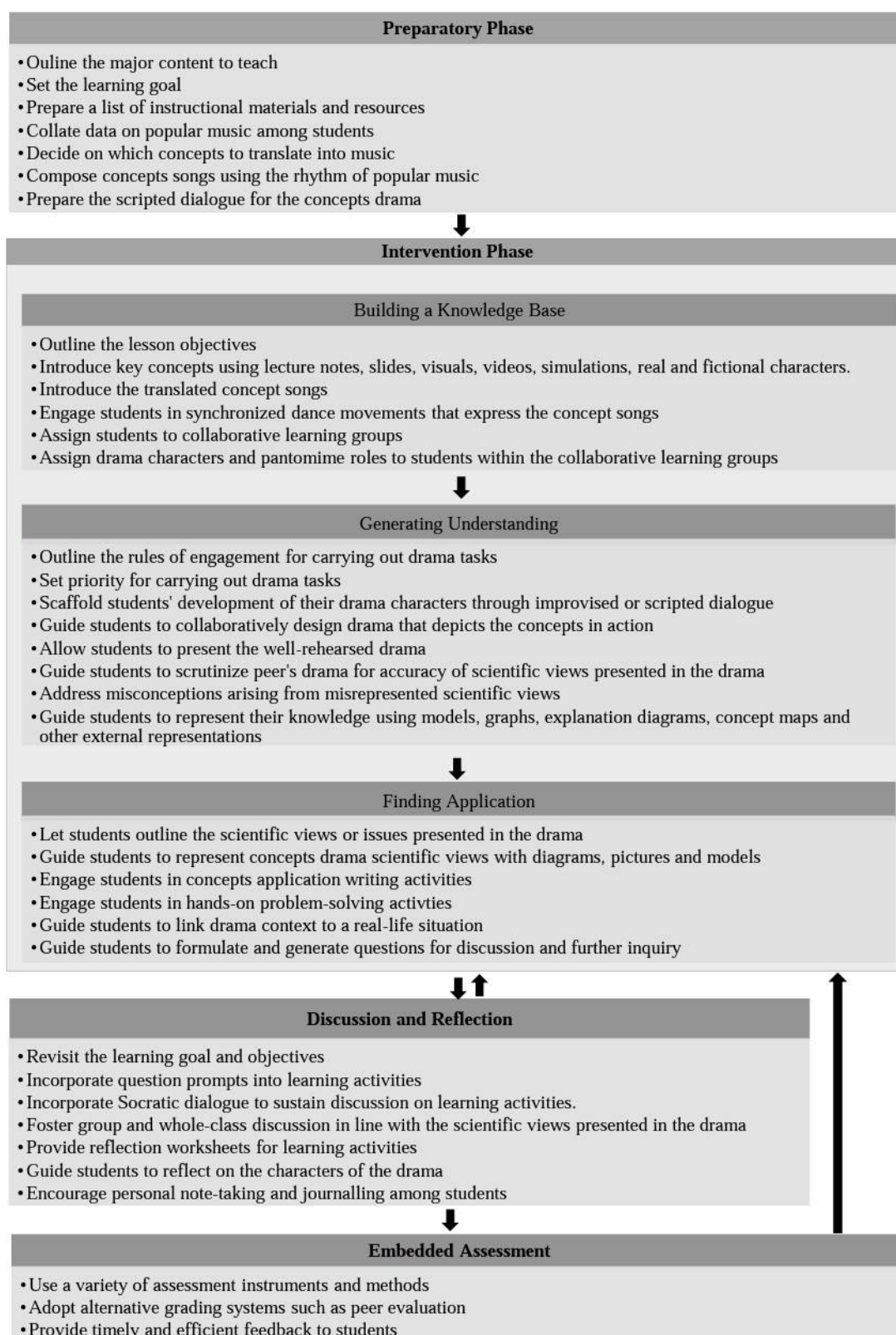


Figure 1. The Performance Arts Enhanced Instructional Model (Oladipo & Akhigbe, 2022).

## Research Questions

1. What is the impact of the PAEIM on students' conceptual understanding of ecology?  
H1a: there would be a significant main effect of treatment on students' conceptual understanding of ecology.  
H1b: gender has a significant main effect on students' conceptual understanding of ecology.  
H1c: there is a significant interaction effect of treatment and gender on students' conceptual understanding of ecology.  
H1d: students' conceptual understanding of ecology is significantly shaped by their mental ability.  
H1e: the interaction effect of treatment and mental ability on students' conceptual understanding of ecology will be significant.  
H1f: there would be significant interaction effect of treatment, gender and mental ability on students' conceptual understanding of ecology.
2. What is the impact of PAEIM on students' attitudes towards science?  
H2a: there would be a significant main effect of treatment on students' attitudes towards science.  
H2b: there is a significant main effect of gender on students' attitudes towards science.  
H2c: there is a significant interaction effect of treatment and gender on students' attitudes towards science.  
H2c: there is a significant main effect of mental ability on students' attitudes towards science.  
H2e: the interaction effect of treatment and mental ability on students' attitudes towards science will be significant.  
H2f: there would be a significant interaction effect of treatment, gender and mental ability on students' attitudes towards science.

## Methods

The participants comprised 211 senior secondary school students (101 males and 110 females) drawn from intact classes in two secondary schools located in education district two in Lagos State. Two intact classes from the selected secondary schools were randomly assigned to the experimental or the control group respectively. The study adopted the quasi-experimental research design comprising treatment at two levels (experimental and control groups) while gender (male and female) and mental ability (low, moderate and high) were incorporated as moderator variables.

The Student Mental Ability Test (SMAT) developed by the Australian Council of Educational Research (ACER) was administered and the scores obtained were used to group the students into low (39% and below), moderate (40%-74%) and high (75% and above) ability groups respectively. The reliability of SMAT was determined using Kuder Richardson 20 (kr-20) and a reliability coefficient of 0.78 was obtained. The 20 items two-tier diagnostic Ecology Concept Test (ECT) was designed by the researchers based on the adaptation of the wordings of previous items for assessing secondary school students' conceptual understanding of ecology concepts (see Beal, Krall & Wymer, 2012; Butler, Simmie & Grady, 2015; Ozcan, Tekkaya & Geban, 2004). The first tier of each item in the ECT examined ecology content knowledge with three distracters and one key. The second tier comprised four reasons for the first tier. These reasons included one scientifically acceptable answer and three misconceptions. According to Haslam and Treagust (1987) two-tier multiple-choice instruments are notable for exposing students' misconceptions because they focus on detecting students' reasons behind their choices of answers. A pilot test of ECT returned a Kuder Richardson 20 reliability coefficient of 0.88. Finally, the modified Attitude Towards Science Inventory (mATSI) revalidated by Tai, Ryoo, Skeeles-Worley, Dabney, Almarode and Maltese (2022) was adopted and used to measure students' attitudes towards science. The mATSI is a reliable, valid and shortened version of the original Attitude Towards Science Inventory (ATSI) developed by Goglin and Swartz in 1992. The mATSI includes the subscales: perceptions of the teachers, anxiety towards science, value of science to society, self-confidence in science and desire to do science. The mATSI was measured under a five-point Likert response format ranging from strongly agree (5 points) to strongly disagree (1 point). The Cronbach's alpha reliability for mATSI was 0.96 indicating the high reliability of the instrument.

The targeted ecology concepts were translated to concept songs by the researchers while the concept for the science drama and lesson plans were co-created by the researchers and the biology teacher who implemented the PAEIM before the administration of the pre-test instruments. The biology teacher received two weeks of pedagogical training on the implementation of three lesson plans (80 minutes each) covering basic ecology concepts, energy and nutrient cycle, and abiotic and biotic components of an



ecosystem while leveraging the PAEIM stages. In one of the ecology lessons, the rhythm of a popular song from an Afro-pop Nigerian artist titled “Duduke” by Simi was translated into ecology concept songs. In another instance, the students performed the Nigerian traditional acrobatic “Atilogu” dance to illustrate the pyramid of energy and number. The students also acted a science drama which portrayed the lion as the king of the jungle to explain the concepts of the food chain and food web. The other biology who taught the control group implemented lessons covering the same highlighted ecology topics using the conventional instructional approach. The teaching phase of the research procedure lasted for four weeks. Finally, the pretest instruments were administered to the entire students to wrap off the procedures.

## Results

Initial findings from the independent sample t-test indicated no significant differences between the experimental and control group for the pretest ( $t_{208} = 1.868$ ,  $p = .846$ ) and pre-attitude ( $t_{209} = 1.390$ ,  $p = .203$ ) respectively. These values showed that the treatment groups were statistically equivalent at the beginning of the experiment.

Empirical findings from Table 1 indicated that the experimental PAEIM group (mean gain = 4.65) outperformed the control group (mean gain = 2.45) on the ecology concepts test. The ANCOVA results from the test of hypothesis H1a revealed a significant main effect of treatment on students’ conceptual

understanding of ecology concept  $\{F_{(1,210)} = 39.497$ ;  $p = .000$ ;  $\eta^2 = .167\}$ . The effective size indicated that treatment accounted for a 16.7% variation in the students’ conceptual understanding of ecology.

**Table 1: Pre-test and post-test mean and SD for main impact of treatment on students’ conceptual understanding of ecology.**

Treatment	N	Pre-test		Post-test	
		Mean	SD	Mean	SD
<b>PAEIM group</b>	132	8.91	1.97	14.46	2.89
<b>Control</b>	79	8.41	1.76	10.86	2.57

The results from Table 2 showed that the females in the experimental group (mean gain = 5.11) outperformed their counterparts in the control group (mean gain = 1.92). Likewise, the males in the experimental group (mean gain = 5.94) outwitted the performance of their counterparts in the control group (mean gain = 3.27). Generally, the female students (mean difference = 3.19) performed better than their male counterparts (mean difference = 2.56) by recording a higher mean difference. Nonetheless, the ANCOVA tests for the hypotheses H1b and H1c revealed a non-significant main effect of gender on the conceptual understanding of ecology  $\{F_{(1,210)} = 1.887$ ;  $p = .171$ ;  $\eta^2 = .009\}$  and a non-significant interaction effect of treatment and gender on the student’s conceptual understanding of ecology concepts  $\{F_{(1,210)} = 1.287$ ;  $p = .258$ ;  $\eta^2 = .006\}$  respectively.

**Table 2: pretest and posttest mean and SD for main effect of gender and interaction effect of treatment and gender on the conceptual understanding of ecology.**

Treatment	Gender	N	Pre-test		Post-test	
			Mean	SD	Mean	SD
<b>PAEIM group</b>	Female	62	9.16	2.22	14.27	2.71
	Male	70	8.69	1.66	14.63	3.04
<b>Control</b>	Female	48	8.54	2.12	10.46	2.81
	Male	31	8.19	.98	11.46	2.04

The results from Table 3 highlighted the performance of students with respect to their mental ability groups. The data synthesized from Table 3 revealed that treatment generally improved the students’ conceptual understanding of ecology in all the mental ability groups. However, the high mental ability group recorded a higher mean difference of 3.39 followed by the moderate ability group (mean difference = 2.97) and low ability group (mean difference = 0.93) in that particular order. Regardless, there was no significant main effect of mental ability on the student’s

conceptual understanding of ecology- H1d  $\{F_{(2, 210)} = 2.729$ ;  $p = .068$ ;  $\eta^2 = .027\}$  neither was there any significant interaction between treatment and mental ability on the student’s conceptual understanding of ecology concepts- H1e  $\{F_{(2, 210)} = .159$ ;  $p = .853$ ;  $\eta^2 = .002\}$ . In addition, the ANCOVA test for hypothesis H1f indicated a non-significant interaction between treatment, gender and mental ability on the conceptual understanding of ecology concepts  $\{F_{(2, 210)} = 1.902$ ;  $p = .152$ ;  $\eta^2 = .019\}$ .

**Table 3: pretest and posttest mean and SD for main effect of mental ability and interaction effect of treatment and mental ability on the conceptual understanding of ecology.**

Treatment	Mental ability	N	Pre-test		Post-test	
			Mean	SD	Mean	SD
PAEIM group	High	54	9.28	1.83	14.96	2.63
	Moderate	34	8.88	2.26	14.35	2.99
	Low	44	8.48	1.83	13.93	3.09
Control	High	24	8.42	2.68	10.71	3.23
	Moderate	30	8.83	1.20	11.33	2.24
	Low	25	7.88	.97	10.44	2.21

The highlights from Table 4 showed that the experimental group who were exposed to PAEIM recorded higher improvements in their attitudes towards science (mean gain = 18.52) than their counterparts in the control group (mean gain = 3.88). The ANCOVA test for hypothesis H2a affirmed that the PAEIM significantly improved the attitudes of students towards science  $\{F_{(1,210)} = 45.627; p = .000; \eta^2 = .188\}$ . This data showed that treatment accounted for an 18.8% variation in the attitude of students towards science.

**Table 4: Pre-attitude and post-attitude mean and SD for main effect of treatment on students' attitudes towards science.**

Treatment	N	Pre-attitude		Post-attitude	
		Mean	SD	Mean	SD
PAEIM group	132	64.46	5.87	82.98	9.91
Control	79	63.36	4.93	72.24	11.91

Data synthesized from Table 5 shows that gender plays a role in shaping students' attitudes towards science

after exposure to the treatment. The female students in the experimental group recorded high attitudinal scores (mean gain = 14.61) than their counterparts who were not exposed to the PAEIM (mean gain = 10.07). Similarly, the male students who were exposed to the PAEIM had more positive attitudes towards science (mean gain = 21.98) than their other male colleagues who were not exposed to the PAEIM (7.03). Generally, the gender differences in the attitudes of students towards science showed that male students had more positive attitudes towards science (mean difference = 14.95) than their female counterparts (mean difference = 4.54). Notwithstanding, The ANCOVA test for hypothesis H2b showed a non-significant main effect on gender on students' attitudes towards science  $\{F_{(1,210)} = .235; p = .629; \eta^2 = .001\}$ . There was however a significant interaction between treatment and gender on students' attitudes towards science-H2c  $\{F_{(1,210)} = 12.373; p = .001; \eta^2 = .059\}$  showing that treatment and gender accounted for 5.9% variations in the attitudes of students towards science.

**Table 5: Pre-attitude and post-attitude mean and SD for main effect of gender and interaction effect of treatment and gender on students' attitudes towards science.**

Treatment	Gender	N	Pre-test		Post-test	
			Mean	SD	Mean	SD
PAEIM group	Female	62	63.95	4.88	78.56	9.04
	Male	70	64.92	6.62	86.90	9.01
Control	Female	48	63.20	5.18	73.27	12.52
	Male	31	63.61	4.58	70.64	10.91

Table 6 revealed that treatment generally improved the attitudes of students towards science irrespective of their ability groups. Empirical findings synthesized from the data presented in table 6 indicated that students from the low mental ability group had a higher mean difference (15.21) than the high ability group (mean difference = 6.51) and moderate ability group (mean difference = 5.44). The ANCOVA tests for the hypothesis H2d revealed a non-significant main

effect of mental ability on students' attitudes towards science  $\{F_{(2, 210)} = 1.485; p = .229; \eta^2 = .015\}$ . Nevertheless, there was a significant interaction between treatment and mental ability on students' attitudes- H2e  $\{F_{(2,210)} = 4.203; p = .016; \eta^2 = .041\}$  and a significant interaction between treatment, gender and mental ability on students' attitudes towards science-H2f  $\{F_{(2,210)} = 3.712; p = .026; \eta^2 = .036\}$ .

**Table 6: Pre-attitude and post-attitude mean and SD for main effect of mental ability and interaction effect of treatment and mental ability on students' attitudes towards science.**

Treatment	Mental ability	N	Pre-attitude		Post-attitude	
			Mean	SD	Mean	SD
PAEIM group	High	54	63.12	4.73	83.22	9.51
	Moderate	34	66.00	6.10	82.44	11.06
	Low	44	64.90	6.67	83.11	9.68
Control	High	24	62.41	5.91	76.00	12.43
	Moderate	30	63.40	4.46	74.40	12.29
	Low	25	64.24	4.42	67.24	9.43

## Discussion

The integration of Arts into Science, Technology, Engineering and Mathematics (STEM) instruction is an agenda that is informing many of the curriculum reforms taking place across the globe. With the emergence of STEAM research, the focus has shifted towards the implementation of innovative science pedagogies that incorporate the Arts (Oladipo & Akhigbe, 2022; Kolovou & Kim, 2020). The study was therefore conceived to assess the pedagogical impact of the Performance Arts Enhanced Instructional Model (PAEIM) on secondary school students' conceptual understanding of ecology concepts and attitudes towards science. Empirical findings from the study indicated that the performance arts enhanced instruction significantly improved students' conceptual understanding of ecology concepts. Due to the fact that the performance arts enrich instruction help students build cognitive structures that enhance their thinking, reflection, engagement, articulation and linkage of ideas to draw reasonable information (Hendrix et al., 2012). This finding aligns with the findings of previous studies where drama-based pedagogies were reported to improve students' understanding of science concepts (Abed, 2016; Duin, 2019; Kolovou & Kim, 2020; Maharaj-Sharma, 2017). In addition, findings from the study suggested that performance arts enhanced instruction can be deployed to improve the achievement of female students who recorded high mean differences compared to their male counterparts. Notwithstanding, the interaction between treatment and gender was not statistically significant. Likewise, there were no significant interactions between treatment and mental ability, treatment, gender and mental ability. These findings disagree with the significant finding of Chen et al. (2017) who reported that the learning of ecology concepts leveraging multimodal representations bridges the gap in the achievement of students from low, moderate and high ability groups.

Empirical findings from the study revealed that students' attitudes towards science significantly improved after exposure to the PAEIM. This is because the PAEIM incorporated design principles that provide the opportunity for meaningful learning in an exciting context (Oladipo & Akhigbe, 2022). This is supported by Abed's (2016); Cokadar and Yilmaz's (2010) and Maharaj-Sharma's (2017) respective findings where students' attitude towards science was reported to have significantly improved after exposure to performance arts enriched science instruction. The collaborative instructional activities replete with scientific drama make learning exciting, fun and interactive for the students which in the long run improves their attitude towards science (Verelas et al., 2010). This also stems from the students' desire to engage in pleasurable learning activities that pique their interests (Jeno, Grtynes & Vandvik, 2017). Further findings from the study revealed significant interactions between treatment and gender, treatment and mental ability, and treatment, gender and mental ability on students' attitudes respectively. These separate findings demonstrate that performance arts enhanced instruction bridges the gap in the attitudes of students irrespective of their gender and mental ability groups. Although, there was no significant main effect of gender and main effect of mental ability on students' attitudes respectively, the significant interactions between treatment and gender, treatment and mental ability however suggest that gender and mental ability play a role in shaping students' attitudes towards science after exposure to the PAEIM instruction.

## Conclusion

The study demonstrates that the integration of the arts and sciences in a single instructional paradigm is promising in enhancing students' conceptual understanding of abstract biology concepts and improving their general attitudes towards science. The



multimodal representation of ecology concepts through dance, drama and music helped the students to build meaningful cognitive structures that enhanced the conceptual understanding and application of ecology concepts. The findings from the present study revalidate earlier findings which affirmed that embedding performance arts into science learning activities promote the effective integration of scientific knowledge and students' co-construction of knowledge in an exciting, fun and interactive instructional context.

### Recommendations

The study recommends that the PAEIM should be massively adopted and implemented within other science domains like physics and chemistry. In addition, science teachers should be trained to implement the PAEIM across multiple instructional contexts through science teachers' professional development and community of practice. Finally, future research should adopt the mixed methods research design to provide robust qualitative and quantitative data that enhances the understanding of STEAM pedagogical practices and challenges that might be encountered with the integration of performance arts into science learning activities.

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