

Investigating the Effect of Artificial Intelligence on Chemistry and Physics Students' Achievement and Conceptual Change in Heat Change in SSS2 in Rivers State

ZUDONU, Onisoman Chuks, Ph.D., OSIAH, Christian Udno., OGBU, Magnus Onyemaechi., OSU, Azuanamibebi Derikuma, NDUKWU, Didacus Emeka., AFOLABI, Blessing Adejoke., JOHN, Jennifer Peniel & NKISA, Osiagor Destiny

Department of Chemistry Education & Physics Education
Federal College of Education (Technical) Omoku, Rivers State, Affiliated to University of Nigeria, Nsukka, Nigeria
onisoman.zudonu@fctomoku.edu.ng

DOI: [10.56201/ijccp.v10.no3.2024.pg42.66](https://doi.org/10.56201/ijccp.v10.no3.2024.pg42.66)

Abstract

This study investigated the effect of Artificial Intelligence (AI) on Chemistry and Physics students' achievement and conceptual change in heat change in SSS2 in Rivers State. A quasi-experimental research design (a non-randomized pretest-posttest control). Purposive sampling technique was used to select 160 participants from sixteen senior secondary schools two (SSS2) Chemistry and Physics students in Rivers West Education zone in Rivers State. Mean, standard deviation, percentage, column chart and pie chart were used to answer the five research questions and independent sample t-test was used to test for the five hypotheses generated at 0.05 level of significance. Chemistry Achievement Test (CAT) and Physics Achievement Test (PAT) together with Conceptual Understanding Test (CUT) were used to determine students' achievement and conceptual change. A structured interview was conducted with the students taught using AI base instruction to examine their experiences and perceptions towards AI-based instruction in heat change. Using test-retest method and Kuder-Richardson's formula-21 yielded a reliability coefficient of 0.78. The results indicated that the Physics students achieved higher in the pretest and posttest with a mean score of 14.40 and 46.35, respectively, against that of the chemistry students taught heat change using AI-based instruction with 12.45 and a posttest score of 44.63 but there was no significant difference in their academic achievement as well as the conceptual change. However, there was a significant difference in the academic achievement and conceptual change between students who received AI-based instruction and those who received traditional instruction as the calculated P-value was less than the alpha value of 0.05. Furthermore, the experiences and perception of the Chemistry and Physics students were generally positive towards the use of AI in the teaching and learning of heat change. The findings of the study provided valuable insights into the potential benefits of integrating AI into Science education, particularly chemistry and physics. The integration of AI in Science education has the potential to transform traditional teaching methods, providing personalized and engaging learning experiences that promote achievement, conceptual change, and positive perceptions of the subjects. It was recommended that further research be conducted to explore the long-term effects of AI-based

instruction on students' achievement and conceptual change in heat change. Therefore, chemistry and physics educators should seize the advantage of AI to enhance students learning outcomes as AI has proven to have these potentials.

Keywords: *Artificial Intelligence, Chemistry, Physics, Achievement, Conceptual Change, Heat Change.*

Background of the Study

The integration of Artificial Intelligence (AI) in education has attracted increasing interest and has shown promising potential in enhancing students' achievement and conceptual understanding (Zheng et al, 2021). This drift of utilizing new technologies for communication has yielded an assortment of technologies that encourage interaction with a user named “virtual information assistants”, which utilizes computer programs to produce human intelligence, thus, making the users believe they are interacting with a real person. This concept is what is known as “Artificial Intelligence (AI)” (Yang et al, 2021). Artificial Intelligence is said to be a computer system that can carry out activities connected with human intelligence, i.e. it can think, read and understand language, provide solutions to problems with foreknowledge into its surroundings (Nilsson, 2009). Thus, AI holds a strong possibility in breaking as well as reducing barriers to education access and at the same time, promote the realization of educational goals by optimization of innovative methods and ICT to enhance students' achievement, conceptual change and overall learning outcomes in the teaching and learning process (Moreno, 2009).

The academic achievement of the science students, which is the outcome of schoolwork, is a major concern for science educators. Considering that Chemistry and Physics are the keystone to the scientific and technological development of any country (Osiah et al, 2021). Research reports have pointed at the low achievement of chemistry and physics students because of poor instructional strategy and ways to improve it (Eze and Bot, 2014; Etukudo, 2002). Due to this importance, placed on scientific literacy, there is the need to integrate AI into the teaching and learning of the sciences, particularly chemistry and physics in other to improve their academic achievement, and in precise terms, topics which students have difficulty in understanding. Among such topics is “HEAT CHANGE”.

The concept of heat change is one of the most popular yet challenging topics in Chemistry and Physics (Mulop et al, 2012). The major difficulty experienced by the chemistry and physics students is that the concept of heat is part of their everyday experiences, hence, leading to misrepresentation when the concepts are introduced to them (Ayyildiz and Tarhan, 2012). Many research works have been carried out in this topic, showing that chemistry and physics students have many misconceptions with heat. Amongst these misconceptions, is that many of the science students cannot explain, state, or clearly identify the differences between Heat and Temperature, leading them to use one in place of the other (Baser, 2006; Baser and Geban, 2007; Olgun, 2008; Tanahoung et al, 2009; Zacharia et al, 2008; Schonborn et al, 2014). Some of the chemistry and physics students make the following statements which show their level of misconception about heat; - Heat cannot be energy, -Heat and Temperature have the same meaning, -contact with the

body tells its temperature, - the highest temperature is the boiling point. (Yeo and Zadnik, 2001). Furthermore, some think of heat as a physical object and as such, can be enclosed (Wiser and Amin, 2001). This goes to show that the students see heat as an entity; meanwhile heat is the transfer of energy because of temperature difference between two bodies. From a scientific point of view, heat is a process and not an entity as the students conceive it to be (Chi, 2008). To overcome this misconception, chemistry and physics students should be taught with innovative methods (Artificial Intelligence) which would bring about modifications in their belief system. This change thus produced what is termed as conceptual change.

Conceptual change refers to the process through which students revise or restructure their existing understanding or mental models of a particular concept or topic. It involves the transformation of students' pre-existing misconceptions, naive theories, or incomplete understandings into more accurate and scientifically accepted conceptions. When students encounter new information or experiences that challenge their existing beliefs or ideas, they may undergo a process of conceptual change. This process involves recognizing the inconsistencies or gaps in their current understanding and actively engaging in cognitive restructuring to accommodate new information (Chi, 2008 & Orji et al, 2019). Conceptual change is not simply about memorizing new facts or information. It goes beyond surface-level learning and involves a deeper transformation of students' mental frameworks. It requires students to critically evaluate their prior knowledge, identify misconceptions, and actively construct new understandings based on evidence and logical reasoning. The process of conceptual change can be complex and challenging. Students may initially resist or have difficulty letting go of their existing beliefs, especially if they have held them for a long time. They may also encounter cognitive conflicts or inconsistencies when new information contradicts their prior knowledge (Ceylan, 2008 & Emmanuel et al, 2013). To facilitate conceptual change, instructional strategies should aim to create a supportive learning environment that encourages active engagement, reflection, and metacognition. Teachers can use various techniques such as engaging students in hands-on activities, providing opportunities for discussion and debate, using concept maps or graphic organizers, and promoting self-reflection. It is important to note that conceptual change is not a linear process. It can vary from student to student and may occur gradually over time or through sudden shifts in understanding. It is also influenced by factors such as prior knowledge, motivation, and the quality of instructional support (Wiser and Amin, 2001). In summary, conceptual change is a fundamental aspect of learning, particularly in chemistry and physics. It involves the transformation of students' existing mental models or misconceptions into more accurate and scientifically accepted conceptions. By promoting conceptual change, educators can help students develop a deeper and more meaningful understanding of the concepts and principles they are studying.

Statement of the Study

This study aims to investigate the effect of AI on Chemistry and Physics students' achievement and conceptual change in heat change in SSS2 in Rivers State. The contributions of chemistry and physics in nation building cannot be overemphasized. Therefore, the reviewed literature in chemistry and physics have shown that the various instructional methods that have been used in teaching chemistry and physics have not improved students' academic achievement

and misconceptions over the years to any significant extent. This suggests that the possibility of students to enlist in chemistry and physics related courses in tertiary institutions is entirely remote. So, we may not have the needed doctors, pharmacists, microbiologists, engineers, radiologists, chemistry, and physics educators, etcetera, and this underscores doom for such a nation as development would be hampered and stunted and solving societal problems may not be sustained. Thus, this study sought to address the issues of poor achievement and misconceptions as they have been shown to be products of teaching methods (Zudonu, 2013). Several questions remain unanswered but posing one among the lots is whether chemistry and physics teachers utilize research findings on innovative instructional methods in classroom delivery?

Purpose of the Study

The purpose of the study includes.

1. To determine the effect of AI on the academic achievement of SSS2 Chemistry and Physics students in heat change in Rivers State?
2. To investigate the effect of AI on the conceptual change of SSS2 Chemistry and Physics students in heat change in Rivers State?
3. To ascertain significant differences in academic achievement between students who receive AI-based instruction and those who receive traditional instruction in heat change?
4. To determine significant differences in conceptual change between students who receive AI-based instruction and those who receive traditional instruction in heat change?
5. To examine the experiences and perceptions of SSS2 Chemistry and Physics students towards AI-based instruction in heat change?

Research Questions

1. What is the effect of AI on the academic achievement of SSS2 Chemistry and Physics students in heat change in Rivers State?
2. What is the effect of AI on the conceptual change of SSS2 Chemistry and Physics students in heat change in Rivers State?
3. What are the significant differences in academic achievement between students who receive AI-based instruction and those who receive traditional instruction in heat change?
4. What are the significant differences in conceptual change between students who receive AI-based instruction and those who receive traditional instruction in heat change?
5. What are the experiences and perceptions of SSS2 Chemistry and Physics students towards AI-based instruction in heat change?

Hypotheses

1. There is a significant difference in the academic achievement of SSS2 Chemistry and Physics students taught heat change using AI-based instruction in Rivers State.
2. There is a significant difference in the conceptual change of SSS2 Chemistry and Physics students taught heat change using AI-based instruction in Rivers State.
3. There is a significant difference in academic achievement between students who received AI-based instruction and those who receive traditional instruction in heat change.

4. There is a significant difference in conceptual change between students who received AI-based instruction and those who receive traditional instruction in heat change.
5. There is a significant difference in experiences and perceptions of SSS2 Chemistry and Physics students towards AI-based instruction in heat change.

Theoretical Framework (Cognitive Conflict)

Since in the 90's, cognitive conflict which has its root in the constructivist learning theory have been largely used in science education (Lee et al, 2003; Kim et al, 2002; Stem, 2002). Cognitive conflict is seen as a state in which a students' mental cognition is troubled by external information which do not conform to their present knowledge, hence the need to adjust to accept and accommodate the scientific knowledge by rejecting the alternative conception (Foster, 2011). Cognitive conflict models follow the process of ascertaining the present knowledge of the student, presenting external information to cause conceptual change in the form of texts, concept maps, graphs, interviews and in the present study of Artificial Intelligence (AI) and afterwards, evaluation of the present knowledge and the previous knowledge to determine the degree of conceptual change in the student. Furthermore, the cognitive conflict model developed by Lee and Kwon (2001) also had three stages, which is the preliminary stage (the stage before cognitive conflict), cognitive conflict stage and the resolution stage (where the student accept or reject the new knowledge so presented) (Lee et al, 2003). Relating this to the present study, when chemistry and physics students with misconceptions on heat are presented with learning materials using AI, this will cause or stir a cognitive conflict leading to a conceptual change on the chemistry and physics students.

Artificial Intelligence (AI) in Education

Education which is as old as man has been flexible and ready to incorporate new advancement in technology. Though, before the emergence of ICT and its kits in the educational sector, teaching and learning have sustained itself by the traditional face-to-face method (Chen et al, 2020). In this present age, referred to as "digital age" Artificial Intelligence (AI) has become the tool needed to achieve the goals of education in various ways, providing education with approaches to problem solving, decision making, reasoning and intelligence (foresight) (Seo et al, 2021). The introduction of AI into the educational sector has impacted substantially in the sector in many ways among which are,

Worldwide Accessibility to Education and Individualized Learning

Artificial Intelligence individualized learning for students according to their strength and weakness, keeping track of the progress by accessing their knowledge and adjusts automatically to the needs and necessities of the student. Artificial Intelligence has made education universally accessible notwithstanding your location (Urban or Rural), ethnic, tribe, race, language, or gender. AI can simply be said to be "all-encompassing and unbiased education for all". AI enables one to attend classes from anywhere and everywhere in the world. It allows for collaborative learning even from different localities, making teachers that utilize enormous amount of time on other administrative activities to save and have adequate time for their students (Holmes et al, 2021).

Effective Teaching and Learning

Artificial Intelligence has entered the four walls of the classroom and has drastically affected and changed the traditional teaching and learning process. Just by sitting in the classroom, students can access, retrieve unlimited information, content, learning materials and utilize same without confusion as AI provides guidance and support to the students. There are many AI based applications now utilized in the teaching and learning process that help the teachers become more effective in the classroom. For instance, AI provides the teacher with appropriate teaching aid, automatic assessment (which reduces workload), detection of plagiarism work and gives feedback about the overall progress of the students. With AI, a student can be engaged in learning/academic activities without the physical presence of the teacher, which is not to say that AI is replacing or taking over the role of the teacher in the classroom (Sadiku et al, 2021).

Effective Assessment and Evaluation

Assessment and education go together, without education there will be no assessment and without assessment there will be no education. Assessment which is the action carried out to determine and examine the nature, value, or quality of education, is an important factor as it gives wide information about the student and system if done properly, timely and without mistake. Most of the problems and challenges encountered in education are poor assessment and evaluation. But with the presence of AI in the educational sector, assessment and evaluation is different, as AI assessment system can be utilized to access students' level of knowledge, understanding, skills, perspective, and confidence level. If adequate information needed like curriculum, subjects and activities of learning and steps taken by the learner is supplied, results can be published at a go using AI assessment systems. AI has also been utilized in the grading of test scores (multiple-choice questions), checking of student's assignment, generating of homework, and even used in admission processes (Luckin, 2017; Kengam, 2020).

Effective Help for Physically Challenged Learners

Tambekar (2019) reported that about 15% of the population of the world is challenged physically with no access to education. But with the arrival of AI, all physically challenged learners can have access to education ranging from the visual impaired, hearing impaired to locomotor disability. Learners with locomotor disability can access the classroom from their geographical location without the need to move, learning at their own pace. AI help the hearing impaired to read and write using sign language as texts are converted into sign language for easy understanding. AI also read texts in different languages to the hearing of the visually impaired and can describe pictures to their understanding and appreciation. With AI no human whether disabled or not will remain uneducated (Tambekar, 2019; Kengam, 2020).

Summarily, Artificial Intelligence entering the educational sector has revolutionized the teaching and learning process, granting access to universal quality education to all, reducing the workload of the teacher while galvanizing the students to access unlimited knowledge from the comfort of their homes and classes and at the same time assessing and evaluating their academic performance with ease while keeping track of their progress. Therefore, chemistry and physics

educators should seize the advantage of AI to enhance the academic achievement and concept change of chemistry and physics students as AI has proven to have these potentials.

Methodology

The research design adopted in this study is quasi-experimental (a non-randomized pretest-posttest control). Purposive sampling technique was used to select 160 participants from sixteen senior secondary schools two (SSS2) Chemistry and Physics students in Rivers West Education zone in Rivers State. The population consisted of 80 Chemistry students (37 males and 43 females) and 80 Physics students (44 males and 36 females) drawn from senior secondary schools in the state. Treatment and Control groups were used. The treatment group (those taught heat change using AI) consisted of 39 females and 41 males, which are made up of 22 female and 18 male Chemistry students and 17 female and 23 male Physics students. While the control group (those taught heat change using the traditional method) consists of 40 females and 40 males, which are made up of 21 female and 19 male Chemistry students and 19 female and 21 male Physics students. The instrument used for data collection consisted of two parts. Part A was titled "Physics Achievement Test" (PAT) for Physics students and "Chemistry Achievement Test" (CAT) for Chemistry students. Part A which contains twenty (20) multiple-choice questions (having 3 distracters and one correct option) was used to measure academic achievement using pretest and posttest. Each correct answer was scored 3 marks, giving a maximum mark of 60 and minimum mark of 0. Part B was titled "Conceptual Understanding Test" (CUT), which made use of pretest and posttest to measure student's conceptual change. Part B holds fifteen (15) conceptual questions and the answers provided by the students were scored under three scales, Full Understanding (FU), Partial Understanding (PU) and No Understanding (NU). The students that got the right concept behind the question was scored 2 marks showing Full Understanding (FU), the students that answered the questions partly or halfway was scored 1 mark indicating Partial Understanding (PU) and the students that failed the questions were scored 0 mark showing No Understanding (NU) of the concept. Furthermore, structured Interview was conducted with the students taught using AI to examine their experience and perception towards AI-based instruction. And afterwards, the qualitative data was converted into quantitative data by assigning values to the qualitative data to test the hypotheses generated. Those that expressed doubt, fear, uncertainty in their responses were assigned a value of one (1) while those that expressed interest, fascination, attractiveness, and glamour of the use of AI were assigned a value of two (2). To ensure validity, the research instruments were face validated by two experts in the fields of Chemistry education and Physics education respectively. Using test-retest method and Kuder-Richardson's formula-21 yielded a reliability coefficient of 0.78, therefore on the basis of high reliability index the research instrument was deemed suitable to carry out the study.

Results

The results of the study were analyzed using mean, standard deviation, percentage, column chart and pie chart. Meanwhile, inferential statistics such as independent t-test was used to determine difference between variables involved in this study. Decision making was based on; reject the hypothesis if the calculated p-value is greater than the alpha value, 0.05, otherwise do not reject.

Research Question 1: What is the effect of AI on the academic achievement of SSS2 Chemistry and Physics students in heat change in Rivers State?

Table1: Showing Mean Achievement Scores of SSS2 Chemistry and Physics Students taught Heat Change Using AI-Base Instruction.

	<i>Chemistry Group (N = 40)</i>		<i>Physics Group (N = 40)</i>	
	<i>(\bar{x})</i>	<i>SD</i>	<i>(\bar{x})</i>	<i>SD</i>
<i>Pre-test</i>	12.45	6.28	14.40	5.78
<i>Post-test</i>	44.63	7.07	46.35	7.03
<i>Mean gain score</i>	32.18		31.95	

It can be seen from the above table, that the achievement of the Physics students seems to be greater both in pretest and posttest scores. However, the mean gain score of the Chemistry students was higher than that of the Physics students. To know if this observed difference was significant, hypothesis one was tested.

Research Question 2: What is the effect of AI on the conceptual change of SSS2 Chemistry and Physics students in heat change in Rivers State?

Table 2: Showing the Conceptual Change of Chemistry and Physics Students taught Heat Change Using AI-Based Instruction.

S/N	Items	Variables	Pre-Conceptual Change			Post Conceptual Change		
			NU	PU	FU	NU	PU	FU
1.	In which phases of matter are molecules capable of changing their positions? Give reason for your answer.	Chemistry	14	26			11	29
			35.0%	65.0%			27.5%	72.5%
		Physics	20	20			10	30
			50.0%	50.0%			25.0%	75.0%
2.	When two bodies of different temperature are in contact, what is the overall direction of heat transfer? And if they come to equilibrium, what does it mean?	Chemistry	17	21	2		10	30
			42.5%	52.5%	5.0%		25.0%	75.0%
		Physics	20	16	4		9	31
			50.0%	40.0%	10.0%		22.5%	77.5%
3.	What are the different methods of heat transfer?	Chemistry	20	17	3		9	31
			50.0%	42.5%	7.5%		22.5%	77.5%
		Physics	17	21	2		6	34
			42.5%	52.5%	5.0%		15.0%	85.0%
4.		Chemistry	17	22	1		10	30
			42.5%	55.0%	2.5%		25.0%	75.0%

	Explain the transformation of states by heat transfer.	Physics	16 40.0%	24 60.0%			15 37.5%	25 62.5%
5.	Explain the concept of expansion produced by heat.	Chemistry	16 40.0%	23 52.5%	1 2.5%		13 32.5%	27 67.5%
		Physics	18 45.0%	21 52.5%	1 2.5%		9 22.5%	31 77.5%
6.	Can sound waves produce heat? Explain.	Chemistry	19 47.5%	18 45.0%	3 7.5%		8 20.0%	32 80.0%
		Physics	20 50.0%	18 45.0%	2 5.0%		6 15.0%	34 85.0%
7.	What is the difference between heat and temperature?	Chemistry	24 60.0%	14 35.0%	2 5.0%		8 20.0%	32 80.0%
		Physics	14 35.0%	23 57.5%	3 7.5%		12 30.0%	28 70.0%
8.	What is the relationship between temperature and kinetic energy?	Chemistry	18 45.0%	20 50.0%	2 5.0%		10 25.0%	30 75.0%
		Physics	18 45.0%	20 50.0%	2 5.0%		5 12.5%	35 87.5%
9.	The unit of rate of heat transfer is ____? Explain why.	Chemistry	19 47.5%	20 50.0%	1 2.5%		10 25.0%	30 75.0%
		Physics	21 52.5%	16 40.0%	3 7.5%		8 20.0%	32 80.0%
10.	What is a black body?	Chemistry	18 45.0%	20 50.0%	2 5.0%		13 32.5%	27 67.5%
		Physics	18 45.0%	20 50.0%	2 5.0%		10 25.0%	30 75.0%
11.	What is the difference between diffusion and radiation heat transfer?	Chemistry	15 37.5%	22 55.0%	3 7.5%		3 7.5%	37 92.5%
		Physics	15 37.5%	23 57.5%	2 5.0%		15 37.5%	25 62.5%
12.	What is the difference between forced convection and natural convection?	Chemistry	18 45.0%	22 55.0%			9 22.5%	31 77.5%
		Physics	19 47.5%	21 52.5%			7 17.5%	33 82.5%
13.	How is heat transfer related to temperature?	Chemistry	20 50.0%	18 45.0%	2 5.0%		6 15.0%	34 85.0%
		Physics	17 42.5%	21 52.5%	2 5.0%		9 22.5%	31 77.5%
14.	When heat transfers into a system, is the	Chemistry	17 42.5%	22 55.0%	1 2.5%		9 22.5%	31 77.5%
		Physics	19	19	2		8	32

	energy stored as heat? Explain.		47.5%	47.5%	5.0%		20.0%	80.0%
15.	What three (3) factors affect the heat transfer that is necessary to change an object's temperature?	Chemistry	14	25	1		9	31
			35.0%	62.5%	2.5%		22.5%	77.5%
		Physics	18	21	1		11	29
			45.0%	52.5%	2.5%		27.5%	72.5%

Furthermore, figures 1 and 2 below show a column chart of Chemistry and Physics students' responses to the conceptual questions before treatment was applied. While figures 3 and 4 show a pie chart of the overall percentage conceptual change of Chemistry and Physics students before treatment was applied.

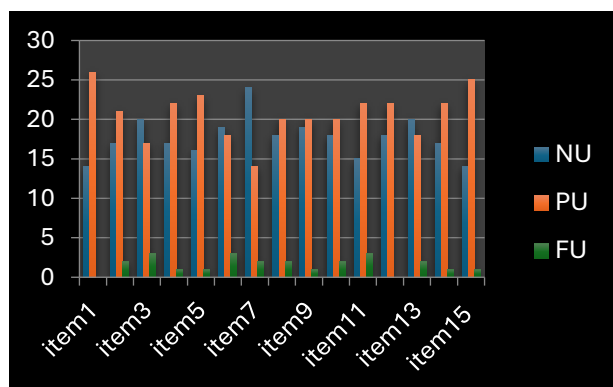


Figure 1: showing chemistry students' responses to conceptual questions.

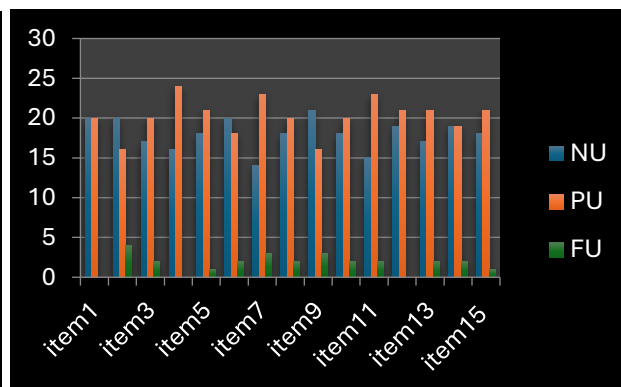


Figure 2: showing physics students' responses to conceptual questions.

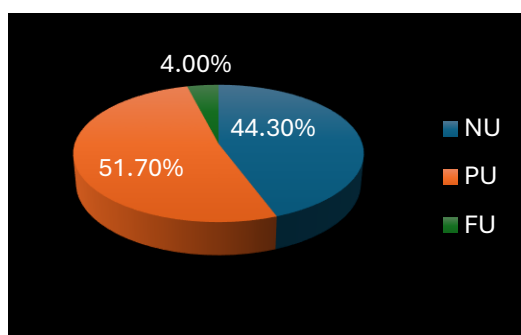


Figure 3: showing chemistry students' overall percentage responses to conceptual questions.

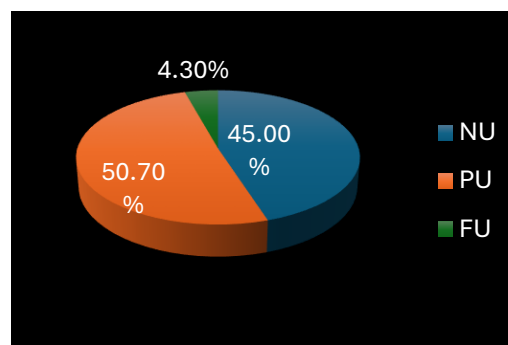


Figure 4: showing physics student's overall responses to

Also, figures 5 and 6 show column chart of Chemistry and Physics students' responses to the conceptual questions after treatment was applied. While figures 7 and 8 show a pie chart of the overall percentage conceptual change of Chemistry and Physics students after treatment was applied.

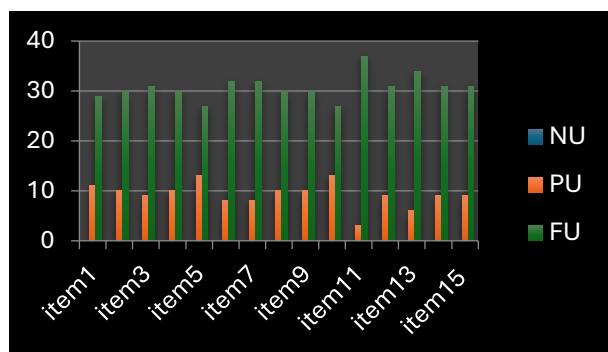


Figure 5: showing chemistry students' responses to conceptual questions.

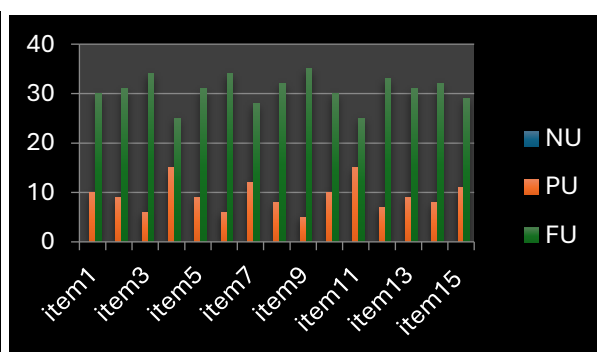


Figure 6: showing physics students' responses to conceptual questions.

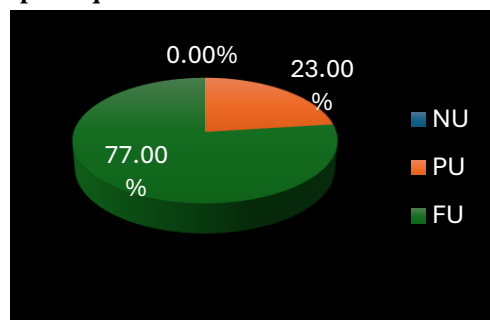


Figure 7: showing chemistry students' overall percentage responses to conceptual questions.

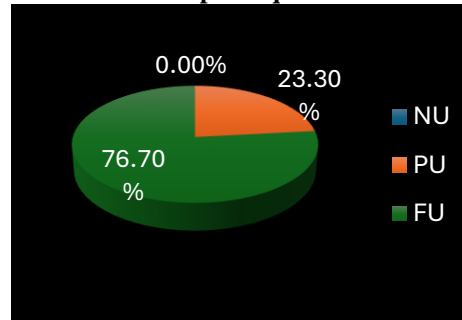


Figure 8: showing physics student's overall responses to conceptual

It is clear from the above information that there exist major conceptual changes between the SSS2 Chemistry and Physics students taught using AI, even though the Chemistry students' conceptual change seems to be above that of the Physics student by a margin of 0.3%. To ascertain if this margin is statistically significant or not, hypothesis 2 was tested.

Research Question 3: Are there any significant differences in academic achievement between students who receive AI-based instruction and those who receive traditional instruction in heat change?

Table 3: Showing Mean Achievement Scores of Treatment and Control Groups taught Heat Change Using AI-Base Instruction and Those Taught Without.

	<i>Treatment Group (N = 80)</i>		<i>Control Group (N = 80)</i>	
	(\bar{x})	<i>SD</i>	(\bar{x})	<i>SD</i>
<i>Pre-test</i>	13.33	6.11	13.52	6.40
<i>Post-test</i>	45.49	7.12	36.11	5.90
<i>Mean gain score</i>	32.16		22.59	

Information in table 3 revealed that before AI-based instruction was utilized on the treatment group, the control group achieved better in the pretest with a mean score of 13.52 as against 13.33 of the treatment group. But after AI-based instruction was utilized the treatment group had a mean achievement score of 45.49 with a mean gain score of 32.16 as against that of the control group with a post mean achievement score of 36.11 and a mean gain score of 22.59. To determine whether the observed difference is significant or not, hypothesis 3 was tested.

Research Question 4: Are there any significant differences in conceptual change between students who receive AI-based instruction and those who receive traditional instruction in heat change?

Table 4: Showing the Conceptual Change of Treatment and Control Groups taught Heat Change Using AI-Based Instruction and Those Taught Without.

S/N	Items	Variables	Pre-Conceptual Change			Post Conceptual Change		
			NU	PU	FU	NU	PU	FU
1.	In which phases of matter are molecules capable of changing their positions? Give reason for your answer.	Treatment	34	46			21	59
			42.5%	57.5%			26.3%	73.7%
		Control	39	41		21	33	26
			48.7%	51.3%		26.3%	41.2%	32.5%
2.	When two bodies of different temperature are in contact, what is the overall direction of heat transfer? And if they come to equilibrium, what does it mean?	Treatment	37	37	6		19	61
			46.2%	46.2%	7.6%		23.7%	76.3%
		Control	30	46	4	21	30	30
			27.5%	57.3%	5.0%	25.0%	37.5%	37.5%
3.	What are the different methods of heat transfer?	Treatment	37	38	5		15	65
			46.2%	47.5%	6.3%		18.7%	81.3%
		Control	30	47	3	22	36	22
			37.5%	58.7%	3.8%	27.5%	45.0%	27.5%
4.		Treatment	33	46	1		25	55
			41.2%	57.5%	1.3%		31.3%	68.7%

	Explain the transformation of states by heat transfer.	Control	34 42.5%	41 51.3%	5 6.2%	22 27.5%	23 28.8%	35 45.7%
5.	Explain the concept of expansion produced by heat.	Treatment	34 42.5%	44 55.0%	2 2.5%		22 27.5%	55 72.5%
		Control	31 38.8%	47 58.7%	2 2.5%	21 26.3%	29 36.2%	30 37.5%
6.	Can sound waves produce heat? Explain.	Treatment	39 48.7%	36 45.0%	5 6.3%		14 17.5%	66 82.5%
		Control	36 45.0%	40 50.0%	4 5.0%	23 28.8%	28 35.0%	29 36.2%
7.	What is the difference between heat and temperature?	Treatment	38 47.5%	37 46.2%	5 6.3%		20 25.0%	60 75.0%
		Control	37 46.2%	41 51.3%	2 2.5%	19 23.7%	30 37.5%	31 38.8%
8.	What is the relationship between temperature and kinetic energy?	Treatment	36 45.0%	40 50.0%	4 5.0%		18 22.5%	62 77.5%
		Control	35 43.7%	45 56.3%	2 2.5%	21 26.3%	27 33.7%	32 40.0%
9.	The unit of rate of heat transfer is ____? Explain why.	Treatment	40 50.0%	34 43.5%	6 7.5%		15 18.7%	65 81.3%
		Control	40 50.0%	40 50.0%		18 22.5%	29 36.2%	33 41.3%
10.	What is a black body?	Treatment	36 45.0%	39 48.7%	5 6.3%		23 28.7%	57 71.3%
		Control	38 47.5%	38 47.5%	4 5.0%	20 25.0%	28 35.0%	32 40.0%
11.	What is the difference between diffusion and radiation heat transfer?	Treatment	30 37.5%	45 56.2%	5 6.3%		18 22.5%	62 77.5%
		Control	39 48.8%	35 43.7%	6 7.5%	24 30.0%	27 33.7%	29 36.3%
12.	What is the difference between forced convection and natural convection?	Treatment	37 46.2%	43 53.8%			16 20.0%	64 80.0%
		Control	40 50.0%	34 42.5%	6 7.5%	22 27.5%	25 31.2%	33 41.3%
13.	How is heat transfer related to temperature?	Treatment	35 43.7%	41 51.3%	4 5.0%		15 18.7%	65 81.3%
		Control	29 36.2%	48 60.0%	3 3.8%	19 23.7%	29 36.3%	32 40.0%
14.	When heat transfers into a system, is the	Treatment	36 45.0%	42 52.5%	2 2.5%		17 21.3%	63 78.7%
		Control	27 33.7%	46 57.5%	7 8.7%	20 25.0%	25 31.2%	35 43.7%

	energy stored as heat? Explain.		33.8%	57.5%	8.7%	25.0%	31.2%	43.8%
15.	What three (3) factors affect the heat transfer that is necessary to change an object's temperature?	Treatment	32	45	3		20	60
			40.0%	56.2%	3.8%		25.0%	75.0%
		Control	36	41	3	23	27	30
			45.0%	52.5%	3.8%	28.8%	33.7%	37.5%

The information contained in table 4 is further analyzed using column chart and pie chart. Figures 9 and 10 below show treatment and control students' responses to the conceptual questions before AI-based instruction was used. And figures 11 and 12 show the level of conceptual understanding of the students before AI-based instruction was used.

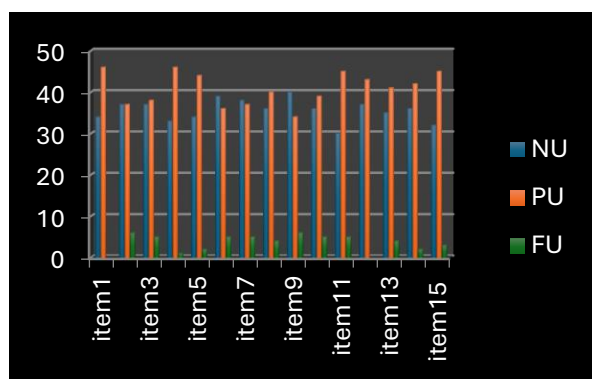


Figure 9: showing treatment students' responses to conceptual questions.

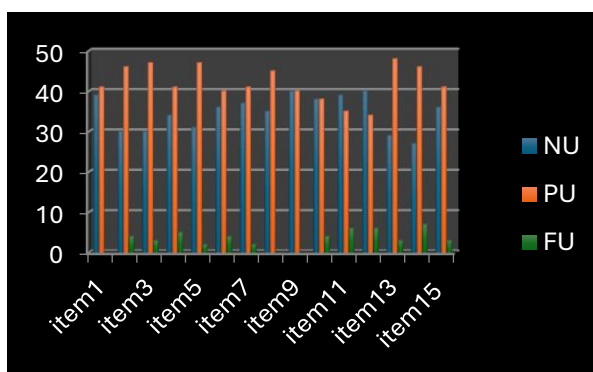


Figure 10: showing control students' responses to conceptual questions.

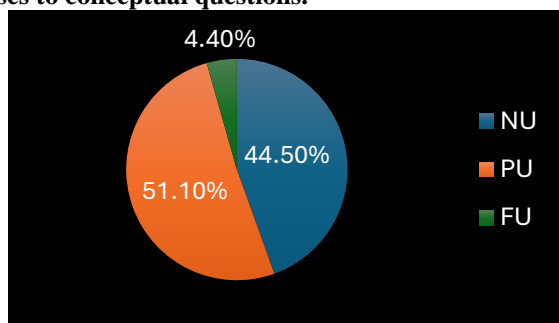


Figure 11: showing treatment students' overall percentage responses to conceptual questions.

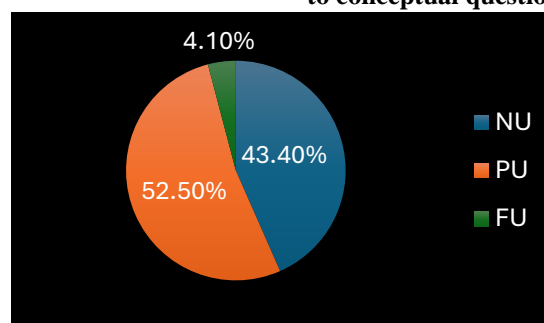


Figure 12: showing control student's overall responses to conceptual questions.

In the same vein, figures 13 and 14 show the responses of treatment and control groups after the utilization of AI-based instruction, while figures 15 and 16 revealed the level of conceptual understanding of both groups after the application of AI-based instruction to the treatment group.

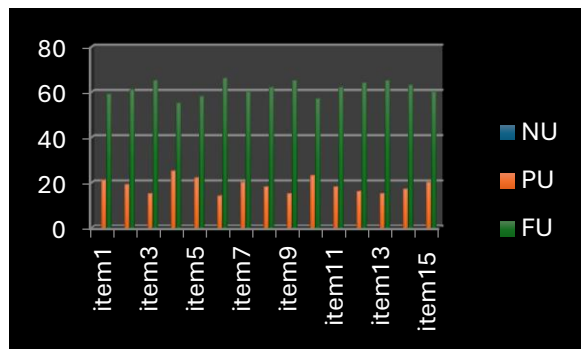


Figure 13: showing treatment students' responses to conceptual questions.

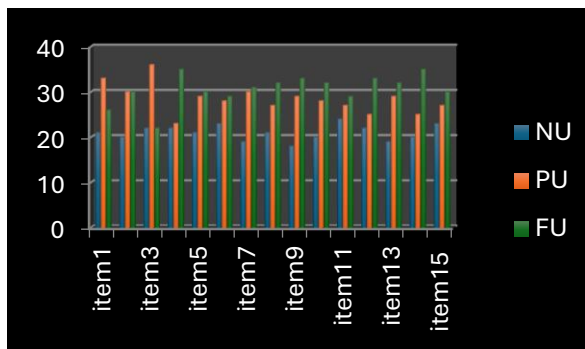


Figure 14: showing control students' responses to conceptual questions.

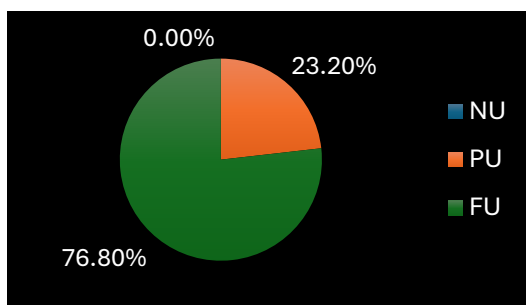


Figure 15: showing treatment students' overall percentage responses to conceptual questions.

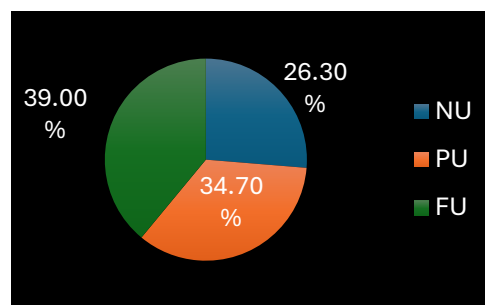


Figure 16: showing control students' overall percentage responses to conceptual questions.

From the pie chart above, its information indicates that the treatment group had more Full Understanding with a percentage of 76.8%, 23.2% Partial Understanding and 0% No Understanding as against the control group with Full Understanding of 39.0%, 34.7% Partial Understanding and 26.3% No Understanding. Hypothesis 4 was tested to determine if this difference was significant.

Research Question 5: What are the experiences and perceptions of SSS2 Chemistry and Physics students towards AI-based instruction in heat change?

In answering this research question, a structured interview was conducted with the students and the table below summarizes the responses of the students.

Table 5: Showing Responses of Chemistry and Physics Students Prospection Towards AI-Based Instruction in Heat Change.

S/N	Interview Questions	Variables	Positive	Negative
1.	What are your thoughts on using AI to teach subjects like heat?	Chemistry	24 60.0%	16 40.0%
		Physics	31 77.5%	9 22.5%
2.	How do you think AI could enhance your learning experience in studying heat?	Chemistry	30 75.0%	10 25.0%
		Physics	26 65.0%	14 35.0%
3.	Do you have any concerns about relying on AI for learning heat concepts?	Chemistry	23 57.3%	17 42.5%
		Physics	28 70.0%	12 30.0%
4.	How do you think AI could benefit teachers in teaching topics like heat?	Chemistry	25 62.5%	15 37.5%
		Physics	30 75.0%	10 25.0%
5.	In what ways do you think AI could improve or change the future of education?	Chemistry	27 67.5%	13 32.5%
		Physics	29 72.5%	11 27.5%

Figures 17 and 18 below go further to show Bar chart of the responses of Chemistry and Physics students' perception towards the use of AI-based instruction.

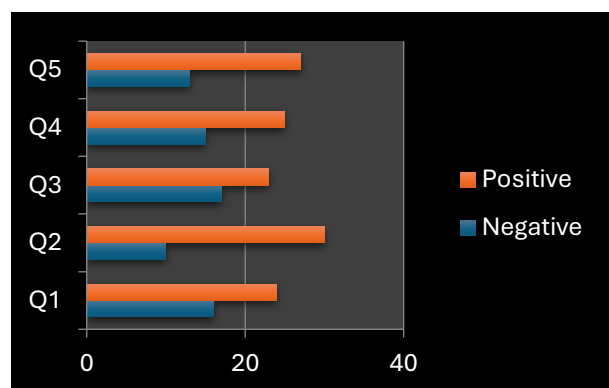


Figure 17: showing chemistry students' responses to interview questions.

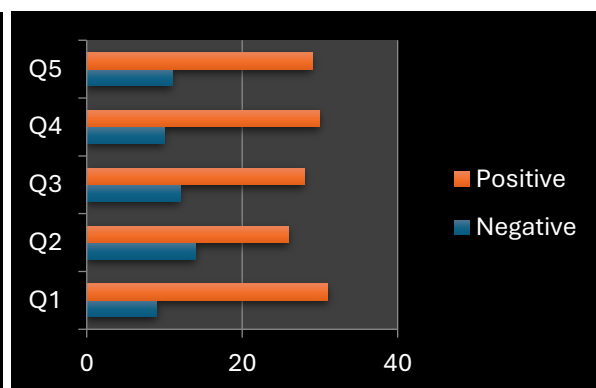


Figure 18: showing physics students' responses to interview questions.

While figures 19 and 20 show the percentage responses of Chemistry and Physics students' perception towards the use of AI-based instruction. From the information displayed, 72.0% of the

Physics students showed a positive perception as against 64.5% of the Chemistry. To see if this difference in perception was significant, hypothesis 5 was tested.

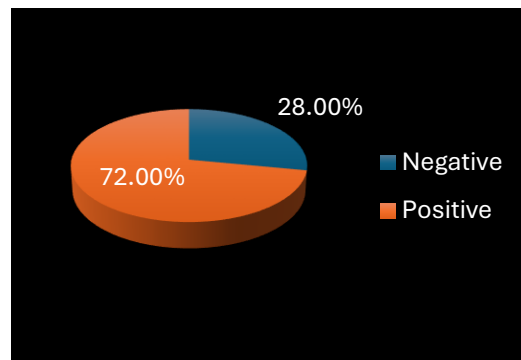
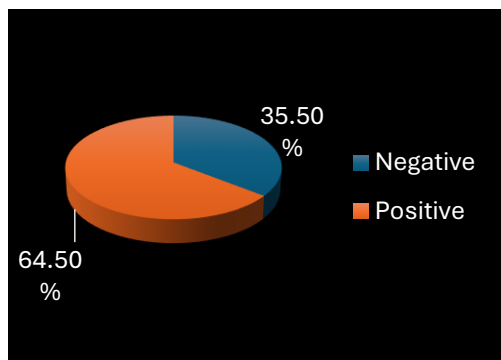


Figure 19: showing chemistry students' percentage responses to interview questions. Figure 20: showing physics students' percentage responses to interview questions.

Hypothesis 1: There is a significant difference in the academic achievement of SSS2 Chemistry and Physics students taught heat change using AI-based instruction in Rivers State.

Table 6: Showing Independent Sample t-test of Significant between the Mean Achievement Scores of Chemistry and Physics Students Taught Heat Change Using AI-Based Instruction.

Variable	(\bar{x})	SD	N	Df	P-Value	t-Crit.	Result
Chemistry	44.63	7.07	40	78	.2835	1.9908	Rejected
Physics	46.35	7.03	40				

Hypothesis 2: There is a significant difference in the conceptual change of SSS2 Chemistry and Physics students taught heat change using AI-based instruction in Rivers State.

Table 7: Showing Independent Sample t-test of Significant between the Conceptual Change of Chemistry and Physics Students Taught Heat Change Using AI-Based Instruction.

Variable	(\bar{x})	SD	N	df	P-Value	t-Crit.	Result
Chemistry	24.20	2.74	40	78	.1088	1.9921	Rejected
Physics	25.13	2.27	40				

Hypothesis 3: There is a significant difference in academic achievement between students who receive AI-based instruction and those who receive traditional instruction in heat change.

Table 8: Showing Independent Sample t-test of Significant between the Mean Achievement Scores of Treatment and Control Groups Taught Heat Change Using AI-Based Instruction and Those Taught Without.

Variable	(\bar{x})	SD	N	df	P-Value	t-Crit.	Result
Treatment	45.49	7.11	80	158	.0000	1.9756	Accepted
Control	36.11	5.89	80				

Hypothesis 4: There is a significant difference in conceptual change between students who receive AI-based instruction and those who receive traditional instruction in heat change.

Table 9: Showing Independent Sample t-test of Significant between the Conceptual Change of Treatment and Control Groups Taught Heat Change Using AI-Based Instruction and Those Taught Without.

Variable	(\bar{x})	SD	N	df	P-Value	t-Crit.	Result
Treatment	24.66	2.56	80	158	.0000	1.9751	Accepted
Control	16.55	2.49	80				

Hypothesis 5: There is a significant difference in experiences and perceptions of SSS2 Chemistry and Physics students towards AI-based instruction in heat change.

Table 7: Showing Independent Sample t-test of Significant between the Perception of Chemistry and Physics Students Taught Heat Change Using AI-Based Instruction.

Variable	(\bar{x})	SD	N	df	P-Value	t-Crit.	Result
Chemistry	8.20	2.20	80	78	.4152	1.9908	Rejected
Physics	8.60	2.11	80				

Discussion

This study aimed at investigating the effect of AI on Chemistry and Physics students' achievement and conceptual change in heat change in SSS2 in Rivers State. Findings in table 1 showed that the Physics students achieved higher in the pretest and posttest with a mean score of 14.40 and 46.35 respectively, against that of the Chemistry students taught heat change using AI-based instruction with a pretest score of 12.45, and a posttest score of 44.63. Meanwhile, the Chemistry students showed better achievement than the Physics students as can be seen from the mean gain score (32.18) of the Chemistry students against 31.95 mean gain score of the Physics students. But the hypothesis test in table 6 revealed that this observed difference was not significant as the P-value (.2835) was greater than the alpha value (0.05), thus the hypothesis was rejected. Meaning that there is no significant difference in the academic achievement of SSS2 Chemistry and Physics students taught heat change in Rivers State. This goes to tell that both groups achieved equally well because of utilization of AI-based instruction. This finding agrees with Crisha et al, (2023); Rizkyana et al, (2024); and Fitrianto et al, (2023). Who in their respective findings agreed that AI-based instruction improves academic achievement notwithstanding the groups involved.

This is because AI-based instruction captives and engages the students making them to want to learn more, leading to improved academic achievement.

Furthermore, research question 2 was answered with data displaced in table 2 and figure 1, 2, 3, 4, 5, 6, 7 and 8. Figures 1 and 2 showed the responses of Chemistry and Physics students towards the conceptual questions under heat change before AI-based instruction was utilized. While figures 4 and 5 showed their percentage responses, where 4.0% of the Chemistry students had Full Understanding (FU), 51.7% had Partial Understanding (PU) and 44.3% had No Understanding (NU). Comparing it against the Physics students with 4.3% Full Understanding, 50.7% Partial Understanding and 45.0% No Understanding of the concepts of heat change. Nevertheless, when AI-based instruction was utilized there was a tremendous change in conception as figures 5 and 6 showed their responses to conceptual questions while figures 7 and 8 showed their percentage responses and it can be seen from it, that both Chemistry and Physics students' moved away from the level of No Understanding to either Partial Understanding or Full Understanding, with Full Understanding having the greater percentage. The Chemistry students had 77.0% Full Understanding and 23.0% Partial Understanding as against 76.7% Full Understanding and 23.3% Partial Understanding of the Physics students. Meaning 0.3% of the Physics students had more Full Understanding than the Chemistry students. However, this observed difference yielded no significant difference as data analysis in table 7 disclosed P-value of .1088 which is greater than the alpha value of 0.05, hence the hypothesis was rejected, and the alternative hypothesis upheld. Therefore, there is no significant difference in the conceptual change of SSS2 Chemistry and Physics students taught heat change using AI-based instruction in Rivers State. The finding agrees with that of Mahliigawati et al, (2023) that integration of AI in the learning of Heat change improved conceptual understanding of the chemistry and physics students as well as their motivation level. Yan (2014) was also in the affirmative that the use of AI can deliver students instant feedback once a misconception has been identified, such feedback can prominently impact learning and teaching process and hence, yield conceptual change in students.

Also, table 3 revealed that in the pretest, the Control group had a higher achievement mean score of 13.52 and SD of 6.40 in contrast to achievement mean score of 13.33 and SD of 6.11 by the Treatment group. But in the posttest, the Treatment group had an achievement mean score of 45.49, SD of 7.12 and a mean gain score of 32.16 while the Control group had an achievement mean score of 36.11, SD of 5.90 and mean gain score of 22.59. This difference in academic achievement was subjected to t-test data analysis and result displayed in table 8 revealed a P-value of .0000 which is less than the alpha value of 0.05, thus the hypothesis was accepted that there is a statistically significant difference in academic achievement of SSS2 Chemistry and Physics students' taught heat change using AI-based instruction in Rivers State. This difference so observed is really because of the different treatment given to both groups. Artificial Intelligence has been proven to improve academic achievement of science students (Chemistry and Physics). This finding is in consonance with those of Huang *et al.*, (2023) and Crisha et al., (2023). In their studies, they found that the present generation learners are taking advantages of AI to improve their academic achievement. The use of AI-based learning enhances learning outcomes by simplifying learning and engaging learners. Trisoni et al. (2023) in his study reported that over 67.9% of the students agreed that AI improved their academic achievement in heat change.

Sunghwan (2022) also found that AI-based instruction affected positively the academic performance of chemistry and physics students in mathematics.

Similarly, data presented in table 4 showed the pre and post conceptual change of chemistry and physics students in Treatment group and Control group. Figures 9 and 10 showed column chart of the responses of the both groups to the conceptual questions before AI-based instruction was used. Figures 11 and 12 showed percentage responses of both groups; where 4.4% of the Treatment group had Full Understanding, 51.1% had Partial Understanding and 44.5% had No Understanding. On the other hand, the Control group had 4.1% having Full Understanding, 52.5% Partial Understanding and 43.4% No Understanding. After treatment (use of AI-base instruction) was given to the Treatment group, 76.8% out of 100% of the students had Full Understanding while the remaining (23.2%) had Partial Understanding. But this was not so for the Control group, as 26.3% still had No Understanding of the concept of Heat Change, while 34.7% had Partial Understanding and 39.0% had Full Understanding as can be seen from figures 15 and 16. Going forward, hypothesis test was carried out to determine if truly there exist a significant difference in the conceptual change of students in both groups (Treatment and Control). Remarkably, data analysis in table 9 showed a statistically significant difference in the conceptual change of both groups. The data analysis returned a P-value of .0000 which is less than the alpha value of 0.05, hence the hypothesis was upheld. Meaning there is a statistically significant difference in the conceptual change of SSS2 Chemistry and Physics students taught heat change using AI-based instruction and those taught without. This finding agrees with that of Hakan et al, (2016), as he reported that when traditional teaching method was employed in teaching heat change, that 16.6 % of the students were found to fully understand the concepts of heat change, while 42.4% gave false or no answers. The remaining 41% either partially understood or misunderstood them. On the other hand, Mahliigawati et al, (2023) maintained that AI is a powerful tool to produce conceptual change in heat change amongst chemistry and physics students. Meanwhile, Rizkyana et al, (2024) asserted that the significant improvement in conceptual change underscores the effectiveness of AI in mastering academic content of heat change.

Research question 5 which explored the perception of the Treatment group was answered using bar chart and pie chart. Figures 17 and 18 show the responses (Positive or Negative) of the Chemistry and Physics students towards the use of AI-based instruction in the teaching and learning of heat change. Figures 19 and 20 revealed that the Physics students showed a more positive perception than their Chemistry counterparts. 72.0% expressed positive experience and perception while 28.0% showed negative perception. While the Chemistry students, 64.5% of the students showed positive perception as against 35.5% that showed negative perception. This indicates that 7.5% more of the Physics Students believe that AI-based instruction helped them learn the concept of heat change well. To know if this difference was significant or not, hypothesis 5 was tested and the data analysis in table 10 unexpectedly gave a P-value of .4152 which is greater than the alpha value of 0.05. Therefore, the hypothesis was rejected, and the alternative hypothesis sustained. On that ground, there is no statistically significant difference in experience and perception of SSS2 Chemistry and Physics students taught heat change using AI-based instruction. This finding agrees with that of Crisha et al., (2023) who found generally positive perception of AI involvement among science students. Furthermore, he reported that science students admitted

AI's potential standing and benefits in their education and imminent professions. Meanwhile, Trisoni et al. (2023) in his study reported that 54.3% of the students showed negative perception as they agreed that AI would reduce interest and natural ability of students reading and studying in their respective field of study as well as the fear of AI taking over the place of the teacher in the classroom.

Conclusion and Recommendation

Conclusively, this study investigated the effect of Artificial Intelligence (AI) on Chemistry and Physics students' achievement and conceptual change in heat change in SSS2 in Rivers State. The findings of the study provided valuable insights into the potential benefits of integrating AI in chemistry and physics education curriculum. The results indicated that students who received AI-based instruction demonstrated significantly higher academic achievement in heat change compared to those who received traditional instruction. The use of AI technologies, such as interactive simulations and virtual experiments, likely provided students with a more interactive and engaging learning experience. This, in turn, contributed to their improved academic achievement in understanding the concepts and principles of heat change.

Furthermore, the study found that AI-based instruction significantly facilitated conceptual change among students. The AI technologies allowed students to visualize and manipulate variables, helping them develop a deeper understanding of the underlying principles of heat change. The interactive nature of AI-based instruction likely encouraged active learning and critical thinking, leading to conceptual change and improved conceptual understanding. Additionally, the study revealed that students who received AI-based instruction had positive experiences and perceptions towards AI-based instruction in heat change. The interactive and immersive nature of AI technologies likely enhanced students' motivation, engagement, and enjoyment in learning. The personalized and adaptive nature of AI-based instruction likely catered to individual students' needs and pace of learning, resulting in a more positive learning experience.

Conclusively, the findings of this study highlight the substantial positive impact of AI on Chemistry and Physics students' learning outcomes in heat change. The integration of AI in Science education in general has the potential to transform traditional teaching methods, providing personalized and engaging learning experiences that promote achievement, conceptual change, and positive perceptions towards the subject.

Recommendations

1. Artificial Intelligence (AI) should be integrated into the senior secondary school curriculum and be used as an innovative teaching method in teaching chemistry education and physics education and science education in general.
2. Government should ensure that AI technologies are effectively integrated into the curriculum, with appropriate training and provision of the necessary tools or gadgets meant for the success of smooth operation and usage of AI for the teachers. This is so because

adequate access to technology and resources is also crucial to ensure equitable learning opportunities for all students.

3. In the same vein, conferences, workshops, symposia etcetera be organized and chemistry and physics teachers and science teachers in general be sponsored fully as this will help teachers not to be antiquated.
4. Further research be conducted to explore the long-term effects of AI-based instruction on students' achievement and conceptual change in heat change.
5. Also, investigating the impact of AI on other topics in chemistry and physics education and exploring the effects of AI in different educational contexts would provide a more comprehensive understanding of the potentials of AI in enhancing students' learning outcomes.
6. The findings of this research be made available for the Ministry of education, national library, tertiary institutions libraries in the country, where students would have access to them.

References

- Ayyildiz, Y., & Tarhan, L. (2012). The effective concepts on students' understanding of chemical reactions and energy. *Hacettepe Hacettepe University Journal of Education*, 42(42), 72-83.
- Baser, M. (2006). Fostering conceptual change by cognitive conflict-based instruction on students' understanding of heat and temperature concepts. *Eurasia Journal of Mathematics, Science and Technology Education*, 2(2), 96-114.
- Başer, M. & Geban, Ö. (2007). The effectiveness of conceptual change instruction on the understanding of heat and temperature concepts. *Research in Science and Technological Education*, 25(1) 115–133.
- Ceylan, H. (2008). *The effect of conceptual change approach on teaching the subject of electricity to sixth-grade students in primary education science and technology course*. Unpublished Master thesis, Gazi University, Ankara.
- Chen, L.; Chen, P.; Lin, Z. (2020). Artificial intelligence in education: A review. *IEEE Access* 2020, 8, 75264–75278. [[CrossRef](#)]
- Chi, M. T. H. (2008). Three types of conceptual change: Belief revision, mental model transformation, and categorical shift. In S. Vosniadou (Ed.), *Handbook of research on conceptual change* (pp. 61-82).
- Crisha, .M.B.P., Jaya, .M.A., Nikkie, .R.A.B., Airosh, .T.C., Ma. Eloisa, .R.E., Jazyca, .B.O.E., Lenell, .J.R.M., & Jorjie, .N. (2023). Artificial Intelligence as a Tool in Increasing Academic Performanc Int. j. adv. multidisc. res. stud. 2023; 3(6):1151-1155.
- Emmanuel I. Orji, Barnabas C. Madu, Christian S. Ugwuanyi, Matthew Cyril, Joy A. Orefor, Oluwatomisin M. Ogundeji, Ugochukwu C. Elejere, Ngozi E. Omeke, Onisoman C. Zudonu & Emmanuel F. Ikwut. (2023). Path Analysis of Situational Affective Characteristics on Conceptual change of Students Exposed to Discrepant Events Instruction in Sound Waves.

Journal of Pharmaceutical Negative Results. Volume 14, Regular Issue 03. (page 2663-2679).

- Etukudo, U.E. (2002). The effect of computer-assisted instruction on gender and performance of junior secondary school students in Mathematics. *Abucus Journal of Mathematics Association of Nigeria*, 27(1), 1-8.
- Eze, J.E., & Bot, T.D. (2014). Effect of concept mapping on secondary school students' achievement in Mathematics in Bichi Education zone, Kano State. *African Journal of Arts, Science and Educational issues*, 2(2), 45-56.
- Fitrianto, I., Hamid, R., & Mulalic, A. (2023). The effectiveness of the learning strategy "think, talk, write" and snowball for improving learning achievement in lessons insya'at Islamic Boarding School Arisalah. *International Journal of Post Axial: Futuristic Teaching and Learning*, 13–22.
- Foster, C. (2011). A slippery slope: Resolving cognitive conflict in mechanics. *Teaching Mathematics and Its Applications*, 30, 216-221.
- Hakan, S., Selahattin.A., Arif.C., Gokhan.C., Musa.U. (2016). Determining Students' Conceptual Understanding Level of Thermodynamics Journal of Education and Training Studies Vol. 4, No. 6; June 2016. ISSN 2324-805X E-ISSN 2324-8068
- Holmes, W., Hui, Z., Miao, F., & Ronghuai, H. (2021). AI and education: A guidance for policymakers. UNESCO Publishing.
- Hwang, S. (2022). Examining the Effects of Artificial Intelligence on Elementary Students' Mathematics Achievement: A Meta-Analysis. *Sustainability* 2022, 14, 13185. <https://doi.org/10.3390/su142013185>
- Huang, A.Y., Lu, O.H., Yang, S.J.H. (2023). Effects of artificial Intelligence-Enabled personalized recommendations on learners' learning engagement, motivation, and outcomes in a flipped classroom. *Computers & Education*. 194:104684. Doi: <https://doi.org/10.1016/j.compedu.2022.104684>
- Kengam, J. (2020). ARTIFICIAL INTELLIGENCE IN EDUCATION. https://www.researchgate.net/publication/347448363_ARTIFICIAL_INTELLIGENCE_IN_EDUCATION.
- Kim, J., Choi, H., Kwon, J. (2002). *Students' Cognitive Conflict Levels by Provided Quantitative Demonstration and Qualitative Demonstration*. Poster presented in Physics Education Research Conference (PERC) August 7-8, 2002 - Boise, ID.
- Lee, G., & Kwon, J. (2001). What do you know about students' cognitive conflict in science Education: A theoretical model of cognitive process. In *Proceedings of 2001 AETS Annual meeting* (pp. 309-325). Costa Mesa, CA: Retrieved from <http://www.rhodes.aegean.gr/ptde>
- Lee, G., Kwon, J., Park, S., Kim, J., Kwon, H., & Park, H. (2003). Development of an instrument for measuring cognitive conflict in secondary-level science classes. *Journal of Research in Science Teaching*, 40(6), 585-603.

- Luckin, R. (2017). Towards artificial intelligence-based assessment systems. *Nature Human Behaviour*, 1(3), 1-3.
- Mahligawati, F., Allanas, .E., Butarbutar, .M.H., and Nordin, .N.A.N., (2023). Artificial Intelligence in Physics Education: a Comprehensive literature review. *Journal of Physics: Conference Series* 2596(2023)012080
- Moreno, R. D. (2019). The arrival of artificial intelligence to education. *RITI Journal*, 7(14), 260–270. <https://doi.org/10.36825/RITI.07.14.022>
- Mulop, N., Yusof, K. M., & Tasir, Z. (2012). A review on enhancing the teaching and learning of thermodynamics. *Procedia-Social and Behavioral Sciences*, 56, 703-712. <http://dx.doi.org/10.1016/j.sbspro.2012.09.706>
- Nilsson, .N.J. (2009). *The Quest for Artificial Intelligence: A History of Ideas and Achievement*. Cambridge: Cambridge University Press. <https://doi.org/10.1017/CBO9780511819346>.
- Olgun, Ö . S. Ç . (2008). Study of the Concepts of Heat and Temperature in Fifth Grade Students with Concept Mapping, *H. U. Journal of Education*, 34, 54-62. mapping. *Hacettepe University Journal of Education*, 34(34).
- Orji, E. I. and Zudonu, O. C. (2019). *Emerging Conceptual Change Model for Sustainable Science Teaching: Cognitive Conflict Instruction in perspective*. School of General Studies University of Nigeria, Nsukka. 2019 Biennial Conference. May 6-9, 2019
- Osiyah, C. U., Osobonye, G.T., & Ofor, W. (2021). Effect of paper-and-pencil concept mapping Strategy on the academic achievement of secondary school Physics students in Rivers State. *THE COLLOQUIUM*, 9(1), 123-134
- Rizkyana, .W.L.P., Laeli, .U.K., & Isnaini, .A.H. (2024). Evaluating the Impact of Artificial Intelligence-Based Learning Methods on Students' Motivation and Academic Achievement *International Journal of Post Axial: Futuristic Teaching and Learning*. 2(1) 151-160 <https://journal.amorfati.id/index.php/postaxial> ISSN 3025-7549
- Sadiku, M. N., Ashaolu, T. J., Ajayi-Majebi, A., & Musa, S. M. (2021). Artificial Intelligence in Education. *International Journal of Scientific Advances*, 2(1), 5-11.
- Seo, K. (2021). The impact of artificial intelligence on learner–instructor interaction in online learning. *Int J Educ Technol High Educ*. <https://doi.org/10.1186/s41239-021-00292-9>
- Schönborn, K., Haglund, J., & Xie, C. (2014). Pupils' early explorations of thermos imaging to interpret heat and temperature. *Journal of Baltic Science Education*, 13(1), 118-132.
- Stern, L. (2002). *Challenging middle-school students' ideas about the inheritance of acquired traits using a history of science case study and a guided discussion*. Paper presented in the third European Symposium on Conceptual Change, June 26-28. 2002, Turku, Finland.
- Tambekar, A. (2019). How Artificial Intelligence AI can Help the Physically Challenged. <https://www.mygreatlearning.com/blog/how-artificial-intelligence-ai-can-help-the-physically-challenged/>

- Tanahoung, C., Chitaree, R., Soankwan, C., Sharma, M. D. & Johnston, I. D. (2009). The effect of Interactive Lecture Demonstrations on students' understanding of heat and temperature: a study from Thailand, *Research in Science & Technological Education*, 27(1) 61–74.
- Trisoni .R., Indah .A., Susi .H., Adam .M., Romi .M., Annisaul .K., David .D., and Nazliati .N. (2023). The Effect of Artificial Intelligence in Improving Student Achievement in High Schools Proceedings of the International Conference on Social Science and Education (ICoSSE 2023), *Advances in Social Science, Education and Humanities Research* 789, https://doi.org/10.2991/978-2-38476-142-5_50
- Wiser, M. & Amin, T. (2001). "Is heat hot?" Inducing conceptual change by integrating every day and scientific perspectives on thermal phenomena, *Learning and Instruction*, 11, 331–355.
- Yan, J., (2014). "A Computer-Based Approach for Identifying Student Conceptual Change". *Open Access Theses*. 289. https://docs.lib.purdue.edu/open_access_theses/289
- Yang, Y., Zhuang, Y., & Pan, Y. (2021). Multiple knowledge representation for big data artificial intelligence: framework, applications, and case studies. *Frontiers of Information Technology & Electronic Engineering*, 22(12), 1551–1558. <https://doi.org/10.1631/FITEE.2100463>
- Yeo, S., & Zadnik, M. (2001). Introductory thermal concept evaluation: Assessing students' understanding. *The Physics Teacher*, 39(8), 496-504.
- Zacharia, Z. C., Olympiou, G. & Papaevripidou, M. (2008). Effects of Experimenting with Physical and Virtual Manipulatives on Student' Conceptual Understanding in Heat and Temperature, *Journal of Research in Science Teaching*, 45(9), 1021-1035.
- Zheng, L., Niu, J., Zhong, L., Gyasi, J.F. (2021). The effectiveness of artificial intelligence on learning achievement and learning perception: A meta-analysis. *Interact. Learn. Environ.* 2021, 1–15. [CrossRef]
- Zudonu, O. C. (2013). Effect of laboratory instructional methods on students' attitude, conceptual change, and achievement in some chemistry concepts at senior secondary school level. *Unpublished Master Thesis. University of Nigeria, Nsukka, Enugu State.*