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EFFECTS OF WEB-BASED INFOGRAPHICS AND WEB-QUEST INTEGRATED INSTRUCTION ON ACADEMIC ACHIEVEMENT AND RETENTION OF PRE-SERVICE PHYSICS TEACHERS AMONG COLLEGES OF EDUCATION, SOUTH-EAST, NIGERIA

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ABSTRACT

This study investigates the effects of Web-based infographics and Web-quest integrated instruction on the learning outcomes of pre-service physics teachers in colleges of education across South-East Nigeria. A quasi-experimental design with a pre-test, post-test, and retention test was employed, involving a population for this study consists of 338 pre-service NCE II physics teachers in Colleges of Education for the 2023/2024 academic session in Southeast Nigeria. The sample for the study consists of NCE II intact class of pre-service physics teachers. A simple random sampling technique was adopted to select eight (8) Colleges of Education offering Physics Education from five (5) South-East States of Nigeria. Afterward, four (4) selected Colleges of Education was purposively assigned to each Experimental Group I and Experimental Group II. These Colleges was purposively assigned based on equivalence (facilities and manpower), school type (government institutions), gender composition (mixed schools), ICT facilities and students' exposure to the Internet. Data collection involved two validated instruments: the Physics Achievement Test (PAT), and the Physics Retention Test (PRT). The Reliability coefficients were determined, with the PRT showing a reliability index of 0.76, while the PAT showing reliability index of 0.81 respectively. Data analysis employed descriptive statistics, t-tests, ANOVA tested at a significance level of 0.05. There was a significant difference in the academic achievement scores of pre-service physics teachers taught using Web-based infographics compared to those taught using the Web-quest integrated instructional platform. The study found a significant difference in the retention scores of pre-service physics teachers between the two groups. There was a significant difference in the academic achievement scores between male and female pre-service physics teachers in both experimental groups. Male and female students in both the Web-based infographic and Web-quest instructional platforms showed different levels of achievement, though the differences were not consistent across groups. The study also found a significant difference in retention scores between male and female students. Male students in the Web-quest group showed better retention scores than their female counterparts, while the retention scores of males and females in the infographics group were more closely aligned. The study concludes that integrating innovative teaching strategies significantly enhances learning outcomes and recommends further research to explore additional instructional methods and their impacts on diverse student populations.

Keywords: Web-based Infographics, Web-quest, Academic Achievement, Retention, Pre-service Physics Teachers, Colleges of Education, and South-East Nigeria

Introduction

Technology has become a transformative force in education, redesigning ways students engage with and understand scientific concepts. The integration of current technologies in science education provides educators and learners with innovative tools to explore, experiment, and comprehend the intricacies of the natural world (Doyan, et. al., 2021). The dynamic combination of science and technology not only closes traditional accessibility gaps but also introduces a range of engaging experiences that cater to various learning styles. As we delve into the discovery of the current technologies in science education, we embark on a journey to uncover the digital, interactive, and virtual aspects shaping the future of how we teach and learn about sciences (Salihu and Abubakar, 2020).

From augmented reality to online simulations, these technologies can transform science education by promoting curiosity, critical thinking, and a deeper understanding of the scientific principles that form the basis of understanding the world (Mishra, 2018). Technology in science education has come a long way and continues to evolve, providing new opportunities for teachers and students alike, the integration of technology in science education is crucial to prepare students for the demands of the modern world. Technology continues to evolve and has become increasingly relevant in the field of science education offering a range of tools for the teaching and learning process. Here are some commonly utilized technologies in science education as Interactive Whiteboards, Smartboards, Online Simulations, Virtual Labs, Augmented Reality (AR) and Virtual Reality (VR), Educational Apps and Games in Science Education,3D Printing, Robotics and Artificial Intelligence (AI), Infographics and Web-Quest (Doyan, et. al., 2021).

Various types of visualizations have always been used in the learning process, and their role in this process is significant (Pakhomova, et al., 2023). This is particularly the case when the use of visual aids is not limited to mere illustration to make the training course more accessible and easier to learn but becomes an organic part of the student's cognitive activity, a means of forming and developing not only visual imagery but also abstract-logical thinking. The modern educational process uses tools for visualizing learning information such as timelines, mind maps, and scribing; infographics are exceptional because web-based infographics are the integration of images and text in a virtually appealing manner characterized by harmonizing colours and shapes, is a modern and inventive approach to presenting information (Salihu and Abubakar, 2020). This method effectively captures the attention of pupils. Using infographics is crucial in effectively communicating information to students' minds. The matter of information organization has emerged as a significant concern in the contemporary day due to the disorder caused by extensive amounts of unprocessed data (Elaldi and Çifçi, 2021). However, With the emergence of various technological novation and tools as

stated above many teachers have adopted the idea of using Web-based infographics and Web-quests to effectively use the Internet in the classroom but no literature has shown the impact of the combination of the two innovative approaches to effective teaching and learning of physics among pre-service physics teachers in Southeast Nigeria.

An infographic is more than a collection of visuals and data; it is a medium for creating links. Infographics provide an excellent way to interpret facts and knowledge and to help students develop their analytical thinking skills. The ultimate aim of an infographic is to integrate facts, details, and visual elements to maximize communication effectiveness. Infographics as an instructional strategy is a visual graphic display that indicates the relationship between facts, concepts, or ideas within a learning activity. The visual representation of infographics provides learners with a systematic framework of insight to be learned. This helps to direct the learners' attention to key concepts and hypothetical relationships. The use of such infographics, thus, promotes understanding and enhances organization and long-term retention of data. It stresses meaningful learning which serves to facilitate learning and minimize boredom on the part of the learners (Alzoubi, et. al., 2023). Finally, an infographic can show a student's ability to sort information, shape relationships, recognize trends, and present the data as more concrete knowledge.

In 1995, Dodge and March introduced Web-quest to the educational community. Dodge's article, Web-quests: A technique for Internet-based learning, allowed educators to see how the Internet could be used in classrooms for inquiry-based teaching and learning. Web-quests were defined as an inquiry-orientated activity in which some or all of the information that learners interact with comes from resources on the Internet. Yonder, (2019) opined that in a typical Web-quest, students were presented with a scenario and a task, usually a problem to solve or a project to complete. The students were given Internet resources and asked to analyze and synthesize the information that resulted in creative solutions. This explanation of Web-quests, along with the implementation by many teachers of Web-quests in their classrooms, often falls short of the true purpose and intended learning outcomes originally designed by Dodge and March (Barack, 2018).

Colleges of Education play prominent roles that engender unprecedented developments in society and these institutions are known as the citadels of knowledge this is why all over the world today especially in developed nations, colleges of education are taken very seriously because of the students produced in this colleges are in the form of learned citizens and are germane to the socio-economic and technological advancement of such nations. Given this, the college of education is viewed as an important organ of investment in human capital development, the contribution of which is tantamount to human and socioeconomic growth and development of societies (Chatzikyrkou, et. al., 2020).

Learning outcomes are statements describing the knowledge, ideas, concepts, interests, skills, and attitudes that students are expected to demonstrate upon completion of a learning experience.

Learning outcomes are the specific knowledge, skills, and abilities that students are expected to possess and acquire upon completion of a course content or materials, program, or degree." (Zhu, et. al., 2021). Learning outcomes are the measurable, noticeable observable outcomes that students achieve or attain as a result of their learning experiences. These authors argue that it is good practice to be explicit about what is expected of learners for learning to be attained. Learning outcomes are the expected outcomes from students which are considered just as assessment criteria for example the achievement and retention of students in a given test or an examination (Abel *et. al.*, 2016).

Gender is a fact of being a male or a female. The influence of gender in educational achievement especially in Physics has been reported in some research studies for example Jugović, (2019) all published on gender influence in achievement, interest, and retention were inconsistent. Some studies favours males against females in Physics achievement and retention while others studies are in favour of female students. However, there is a significant gap in the literature regarding the effectiveness of integrating web-based infographics and web-quests integrated instruction into physics instruction. While some studies have investigated the use of Web-based infographics or Web-quests in education, research is needed to explore the impact of combining these two innovative approaches on learning outcomes in physics education. Therefore, this study aims to investigate the effects of web-based infographics and web-quest integrated instruction on learning outcomes of pre-service physics teachers in Colleges of Education in Southeast, Nigeria, including student achievement, retention, and interest.

Aim and Objectives of the Study

This study aims to investigate the effects of Web-based infographics and Web-quest integrated instruction on learning outcomes of pre-service physics teachers among colleges of education in South-East, Nigeria. Specifically, the study intends to determine the comparative effect of;

1. Web-based Infographics and Web-quest integrated instructional platform on the academic achievement of pre-service Physics teachers.
2. Web-based Infographics and Web-quest integrated instructional platform on the retention ability of pre-service Physics teacher
3. Gender (Male and Female) on the academic achievement of pre-service physics teachers taught with Web-based infographics and Web-quest integrated instructional platform.
4. Gender (Male and Female) on the learning retention of pre-service physics teachers taught with Web-based infographics and Web-quest integrated instructional platform.

Research Questions

Based on the above objectives, the study raised the following research questions:

1. What is the effect of Web-based Infographics and Web-quest integrated instructional platforms on the mean academic scores of Pre-service physics teachers?

2. What is the effect of Web-based Infographics and Web-quest integrated instructional platforms on the retention scores of Pre-service physics teachers?
3. Is there a significant gender (male and female) difference in mean academic achievement scores among pre-service physics teachers taught with web-based infographics and web-quest-integrated instructional platforms?
4. What is the effect of gender (Male and Female) on the mean retention scores of pre-service physics teachers taught with Web-based infographics and Web quest integrated instructional platforms?

Hypotheses

The following null hypotheses will be formulated and tested at 0.05 alpha level of significance in the study:

HO_1: There is no significant difference in the mean academic achievement scores of pre-service physics teachers taught with Web-based Infographics and Web-quest integrated instructional platforms.

HO_2: There is no significant difference in the mean retention scores of pre-service physics teachers taught with Web-based Infographics and Web-quest integrated instructional platforms.

HO_3: There is no significant difference in the mean academic achievement scores of Male and Female pre-service teachers who taught physics with the Web-quest instructional platform.

HO_4: There is no significant difference in the retention scores of Male and Female pre-service physics teachers taught with the Web-quest instruction platform.

Research Method

A quasi-experimental research design and descriptive survey design was used, Pre-test, post-test non-equivalent non-randomized design was used. The design was adopted because it allows the use of intact class. The pre-test was administered before the treatment, while the post-test was administered after the treatment to determine the achievement of physics students. The retention test was administered two weeks after the post-test. The design sketch is shown in Table 1

Table 1 Research Design

Group	Pretest	Treatment	Posttest	Retention
E 1	O_1	X_1	O_2	O_3
E 2	O_1	X_2	O_2	O_3

Key: The interpretations of the layout are as follows

E 1 => (Infographics)

E 1 => (Web-Quest)

O_1 => Pretest, O_2 => Posttest, O_3 => Retention and O_4 => Interest

O_1 O_1 Pretest Observation of Exp I & II

O_1 O_2 Posttest Observation of Exp I & II

X_1 => Treatment for E1 (Experimental group1 Infographics)

X_2 => Treatment for E 2 (Experimental group2 Web-Quest Instruction)

Physics Web-Quest Questionnaire and Infographics Questionnaire (PWEQ and IGQ).

The dependent variables for the study were students' achievement, retention, and interest of students in physics. The independent variables were instructional strategies, which include infographics and web-quest instructional groups.

Population of the Study

The population for this study consists of 338 pre-service physics teachers Colleges of Education for the 2023/2024 academic session in Southeast Nigeria, the geopolitical zones comprise five states, namely Abia, Anambra, Ebonyi, Enugu, and Imo. The region has a population of about 36 million people, around 18% of the total population of the country. The South East is predominantly Igbo ethnically and linguistically. The target population of the study was made up of 338 pre-service NCE eight (8) teachers in the 2023/2024 academic session.

Sample and Sampling Techniques

The sample for the study consists of NCE II intact class of pre-service physics teachers. A simple random sampling technique was adopted to select eight (8) Colleges of Education offering Physics Education from five (5) South-East States of Nigeria. Afterward, the eight (8) selected Colleges of Education was purposively assigned to Experimental Group I and Experimental Group II respectively. These Colleges was purposively assigned based on equivalence (facilities and manpower), school type (government institutions), gender composition (mixed schools), ICT facilities and students' exposure to the Internet. Four (4) of the Colleges of Education was assigned to a web-based infographics instructional platform as experimental group I, and the other Four (4) Colleges of Education was assigned to Web-Quest integrated instructional platform as experimental group II. An intact class (a complete class without single selection), was used for each of the sampled schools for the study.

Table 2: Demographic Distribution of Sample for the Study for NCE 11 Physics

Name of Colleges of Education	Male	Female	Total
Group E1 (Infographics):			
Federal College of Education (Technical) UMUNZE	15	22	37
College of Education, (Technical) ENUGU, State	16	24	40
College of Education, AROCHUKWU, Abia State	17	23	40
Federal College of Education, EHA-AMUFU, Enugu State	19	28	47
Total E1	**67**	**97**	**164**
Group E2 (Web-Quest):			
Alvan Ikoku, Federal College of Education, OWERRI, Imo State	20	33	53
Ebonyi State College of Education, (Technical) IKWO, Ebonyi State	14	19	33
Nwafo Orizu College of Education, NSUGBE, Anambra State	20	28	48
IMO State College of Education, Ihitte/Uboma, Imo State	15	25	40
Total E2	**69**	**105**	**174**

Instruments for Data Collection

Three research instruments were employed by the researcher and use to gather data for the study. They include:

1. Test instrument
   a. Achievement test: Physics Achievement Test (PAT).
   b. Retention test: Physics Retention Test (PAT).
2. Treatment instruments
   a. Web-based infographics Learning Platform (WBIP)
   b. Web-quest Integrate Instruction Platform (WQIIP).

To determine the reliability of the research instrument, a pilot study was carried out in order to determine the problems inherent in the packages before the treatment using 30 NCE II Students from College of Education that was within the population but not part of the sample for the study named Ebonyi state college of education, (Technical) Ikwo Ebonyi State PAT was administered to the students using split-half method. The students were randomly selected (18 males and 13 females) and Physics Achievement Test (PAT) consisting of forty questions was administered to the students at once. Pearson Product Moment Correlation Co-efficient formula was used in calculating the PAT reliability coefficient index of 0.76 while PRT had reliability coefficient index of 0.81 with the following reliability co-efficient Web-Quest 0.86 and Info graphic 0.87 which shows that the instruments were reliable.

Method of Data Collection

In this study, the researcher visited two schools in the first week to seek permission to use students and recruit lecturers as research assistants. The assistants were trained for a week on implementing the instructional platforms, helping guide students with Web-based Infographics and Web-Quest integrated instruction. A pre-test was administered in the third week to assess students' prior knowledge and compare experimental groups. Instruction took place from week's four to eight, with one group using Web-based Infographics and the other using Web-Quest platforms. After eight weeks, a post-test was conducted, followed by a retention test three weeks later, with the test items reshuffled each time. Finally, questionnaires were distributed to gauge students' interest in the platforms. The results were recorded and analyzed, and the study spanned twelve weeks in total.

Method of Data Analysis

The data collected from the administration of research instruments was analysed using descriptive and inferential statistics. Mean and Standard Deviation was used to answer the stated research questions. T-test was used to analyze the pre-test scores. If significant difference exists in the pre-test of the groups, ANCOVA was used to analyze the hypotheses and if difference exist post-hoc was used to identify direction differences among the groups. The data was analyzed using statistical package for social sciences (SPSS) 23.00 version.

Results and Discussion

Pretest Result

To justify the selection of statistical analyses for testing the null hypothesis, an Independent Samples t-test were employed to assess the significance of pretest scores on mean achievement scores and mean interest ratings, respectively. The results of these analyses are presented in Tables 3

Table 3: Summary of Analysis of Independent Samples t-test on Achievement Scores of Experimental Groups at pretest

Group	N	Mean	SD	Df	t-value	P-value
Experimental I - Web-based infographics	164	24.14	5.85	336	0.409	0.683*
Experimental II- Web-Quest-Integrated	174	24.40	5.80			

*Not Significant at 0.05 level

Table 3 presents the Independent Samples t-test results comparing the pretest mean achievement scores of pre-service physics teachers taught using the Web-Based Infographics and Web-Quest-Integrated Instructional Platforms. The analysis yielded a t-value of 0.409 with a corresponding p-value of 0.683, calculated at a 0.05 level of significance ($t(336) = 0.409$, $p > 0.05$). Since the p-value exceeds the 0.05 threshold, the difference is not statistically significant. Consequently, the null hypothesis, which states that there is no significant difference in the pretest mean achievement scores between preservice physics teachers taught using the Web-Based Infographics and Web-Quest-Integrated Instructional Platforms, is accepted. Based on this result, an Independent Samples t-test was used to analysed hypotheses one and two and ANOVA was used to analysed hypotheses three and four respectively.

Analysis of research questions

Research Question One: What is the effect of Web-based Infographics and Web-quest integrated instructional platforms on the mean academic scores of Pre-service physics teachers?

Mean and standard deviations were used to answer this research question and the analysis is presented in Table 4.

Table 4: Mean and Standard Deviation of Achievement Scores of Students Taught using Web-based Infographics and Web-quest integrated instructional Platforms

Group	Strategy	N	Pretest		Posttest		Mean Gain
			$\bar{x}$	SD	$\bar{x}$	SD	
Experimental I	Web-based Infographics	164	24.14	5.85	45.55	8.19	21.41
Experimental II	Web-quest integrated	174	24.40	5.80	53.00	13.53	28.60

Table 4 shows the result of descriptive statistics on achievement scores of preservice physics teachers exposed to Web-based Infographics and Web-quest integrated instructional Platforms at Pretest and Posttest, respectively. The result indicates that the mean and standard deviation scores at Pretest and Posttest for experimental group I (Web-based Infographics) is $\bar{x}$ = 24.14, SD = 5.85 and $\bar{x}$ = 45.55, SD = 8.19, respectively. This gives a mean gain of 21.41 in favour of Posttest. Similarly, the mean and standard deviation scores at Pretest and Posttest for experimental group II (Web-quest integrated) is $\bar{x}$ = 24.40, SD = 5.80 and $\bar{x}$ = 53.00, SD = 13.53, respectively. This gives a mean gain of 28.60 in favour of Posttest. From the results, it could be

deduced that Web-quest integrated instructional method improves academic achievement of preservice physics teachers compared to Web-based Infographics.

Research Question Two: What is the effect of Web-based Infographics and Web-quest integrated instructional platforms on the retention scores of Pre-service physics teachers? Mean and standard deviations were used to answer this research question and the analysis is presented in Table 5.

Table 5: Mean and Standard Deviation of Retention Scores of Students Taught using Web-based Infographics and Web-quest integrated instructional Platforms

Group	Strategy	N	Posttest		Retention		Mean Gain
			$\bar{x}$	SD	$\bar{x}$	SD	
Experimental I	Web-based Infographics	164	45.55	8.19	54.51	9.66	8.96
Experimental II	Web-quest integrated	174	53.00	13.53	59.22	10.32	6.22

Table 5 shows the result of descriptive statistics on retention scores of preservice physics teachers exposed to Web-based Infographics and Web-quest integrated instructional Platforms at posttest and post Posttest, respectively. The result indicates that the mean and standard deviation scores at posttest and post Posttest for experimental group I (Web-based Infographics) is $\bar{x}$ = 45.55, SD = 8.19 and $\bar{x}$= 54.51, SD = 9.66, respectively. This gives a mean gain of 8.96 in favour of post posttest. Similarly, the mean and standard deviation scores at posttest and post posttest for experimental group II (Web-quest integrated) is $\bar{x}$ = 53.00, SD = 13.53 and $\bar{x}$ = 59.22, SD = 10.32, respectively. This gives a mean gain of 6.22 in favour of post posttest. Thus, signifies an improvement in mean retention scores of pre-service physics teachers exposed to Web-based Infographics and Web-quest integrated instructional Platforms. From the above scenario, it could be concluded that Web-based Infographics and Web-quest integrated instructional Platforms are effective in improving mean retention scores of pre-service physics teachers.

Research Question Three: Is there a significant gender (male and female) difference in mean academic achievement scores among pre-service physics teachers taught with web-based infographics and web-quest-integrated instructional platforms?
The mean and standard deviation were used to answer this research question and the analysis presented in Table 6.

Table 6: Mean and Standard Deviation of Achievement Scores of Male and Female Students taught using Web-Based Infographics and Web-Quest-Integrated Instructional Platforms

Group 4	Gender	N	Pretest		Posttest		Mean Gain
			$\bar{x}$	SD	$\bar{x}$	SD	
Experimental I - Web-based infographics	Male	67	22.66	4.55	44.74	8.04	22.08
	Female	97	25.12	6.40	46.08	8.29	20.96
Experimental II- Web-Quest-Integrated	Male	69	25.22	6.24	55.18	12.28	29.96
	Female	105	23.83	5.42	51.49	14.21	27.66

Table 6 shows the results descriptive statistics on achievement scores of male and female preservice physics teachers exposed to Web-based infographics and Web-Quest-Integrated instructional platforms at Pretest and Posttest, respectively. The result indicates that the mean and standard deviation scores of male preservice physics teachers exposed to Web-based infographics at Pretest and Posttest for experimental group I is, $\bar{x}$ = 22.66, SD = 4.55 and $\bar{x}$ = 44.74, SD = 8.04, respectively. This gives a mean gain of 22.08in favour of Posttest. Similarly, the Female pre-service physics teacher exposed to Web-based infographics mean and standard deviation scores at Pretest and Posttest is, $\bar{x}$ = 25.12, SD = 6.40 and $\bar{x}$ = 46.08, SD = 8.29, respectively. This gives a mean gain of 20.96in favour of Posttest. On the other hand, Male preservice physics teacher exposed to Web-Quest-Integrated mean and standard deviation scores at Pretest and Posttest is $\bar{x}$ = 25.22, SD = 6.24 and $\bar{x}$ = 55.18, SD = 10.66, with a mean gain of 29.96 in favour of Posttest. Furthermore, the female pre-service physics teachers exposed to Web-Quest-Integrated mean and standard deviation scores at Pretest and Posttest as, $\bar{x}$ = 23.83, SD = 5.42 and $\bar{x}$ = 51.49, SD = 14.21, with a mean gain of 27.66 in favour of Posttest. From the results, it could be concluded that web-based infographics and web-quest-integrated instructional platforms are effective in improving mean achievement scores of both male and female pre-service physics teachers.

Research Question Four: What is the effect of gender (Male and Female) on the mean retention scores of pre-service physics teachers taught with Web-based infographics and Web quest integrated instructional platforms?

Table 7: Mean and Standard Deviation of Retention Scores of Male and Female Students taught using Web-Based Infographics and Web-Quest-Integrated Instructional Platforms

Group	Gender	N	Posttest		Post Posttest		Mean Gain
			$\bar{x}$	SD	$\bar{x}$	SD	
Experimental I - Web-based infographics	Male	67	44.74	8.04	53.97	9.06	9.23
	Female	97	46.08	8.29	54.87	10.07	8.79
Experimental II- Web-Quest-Integrated	Male	69	55.18	12.28	60.67	10.66	5.49
	Female	105	51.49	14.21	58.22	10.00	6.73

Table 7 shows the results descriptive statistics on retention scores of male and female pre-service physics teachers exposed to Web-based infographics and

Web-Quest-Integrated instructional platforms at Posttest and post Posttest, respectively. The result indicates that the mean and standard deviation scores of male preservice physics teachers exposed to Web-based infographics at Posttest and post posttest for experimental group I is $\bar{x}$ = 44.74, SD = 8.04 and $\bar{x}$ = 53.97, SD = 9.06, respectively. This gives a mean gain of 9.23 in favour of Posttest. Similarly, the Female pre-service physics teacher exposed to Web-based infographics mean and standard deviation scores at posttet and post posttest is, $\bar{x}$ = 46.08, SD = 8.29 and $\bar{x}$ = 54.87, SD = 10.07, respectively. This gives a mean gain of 8.79 in favour of post posttest. On the other hand, Male pre-service physics teacher exposed to Web-Quest-Integrated mean and standard deviation scores at Pretest and Posttest is $\bar{x}$ = 55.18, SD = 12.28 and $\bar{x}$ = 60.67, SD = 10.66, with a mean gain of 5.49 in favour of post posttest. Furthermore, the female pre-service physics teachers exposed to Web-Quest-Integrated mean and standard deviation scores at Pretest and Posttest as, $\bar{x}$ = 51.49, SD = 14.21 and $\bar{x}$ = 58.22, SD = 10.00, with a mean gain of 6.73 in favour of Posttest. From the results, it could be concluded that web-based infographics and web-quest-integrated instructional platforms are effective in improving mean retention of both male and female preservice physics teachers.

Analysis of research hypotheses

Research Hypothesis One

H_{O1}: There is no significant difference in the mean academic achievement scores of pre-service physics teachers taught with Web-based Infographics and Web-quest integrated instructional platforms.

The results for testing null hypothesis one using independent sample t-test at a 0.05 significance level are presented in Table 8.

Table 8: Summary of Analysis of Independent Samples t-test on Achievement Scores of Experimental Groups at Protest

Group	N	Mean	SD	Df	t-value	P-value
Experimental I - Web-based infographics	164	45.55	8.19	366	6.163	0.000*
Experimental II- Web-Quest-Integrated	174	53.00	13.53			

* Significant at 0.05 level

Table 8 shows a sample t test of Posttest mean achievement scores of preservice physics teachers taught using Web-based Infographics and Web-quest integrated instructional platforms. The results indicate that of the t- test analysis of Posttest mean achievement scores of pre-service physics teachers exposed to teach using Web-based Infographics and Web-quest integrated instructional platforms. Revealed a t-value of 6.163with *p* value of 0.00, when computed at 0.05 level of significance ($t_{(366)}$ = 6.163, P < 0.05). Therefore, since the *p*-value of 0.00 is less than 0.05 level of significance, hence, p value is significant.

On the basis of this, null hypothesis one is thereby rejected. Thus, there is significant difference between Posttest mean achievement scores of preservice physics teachers taught -based Infographics and Web-quest integrated instructional platforms.

Research Hypothesis Two: There is no significant difference in the mean retention scores of pre-service physics teachers taught with Web-based Infographics and Web-quest integrated instructional platforms.

The results for testing null hypothesis one using independent sample t-test at a 0.05 significance level are presented in Table 9.

Table 9: Summary of Analysis of Independent Samples t-test on Retention Scores of Experimental Groups at Post Protest

Group	N	Mean	SD	Df	t-value	P-value
Experimental I - Web-based infographics	164	54.51	9.66			
Experimental II- Web-Quest-Integrated	174	59.22	10.32	366	4.331	0.000*

*Not Significant at 0.05 level

Table 9 shows a sample t test of post posttest mean achievement scores of pre-service physics teachers taught using Web-based Infographics and Web-quest integrated instructional platforms. The results indicate that of the t- test analysis of post posttest mean achievement scores of pre-service physics teachers exposed to taught using Web-based Infographics and Web-quest integrated instructional platforms revealed a t-value of 4.331 with *p* value of 0.00, when computed at 0.05 level of significance ($t_{(366)} = 4.331$, $P < 0.05$). Therefore, since the *p*-value of 0.00 is less than 0.05 level of significance, hence, p value is significant.

On the basis of this, null hypothesis one is thereby rejected. Thus, there is significant difference between post posttest mean achievement scores of pre-service physics teachers taught using Web-based Infographics and Web-quest integrated instructional platforms.

Research Hypothesis Three: There is no significant difference in the mean academic achievement scores of Male and Female pre-service teachers who taught physics with the Web-based Infographics and Web-quest integrated instructional platforms.

The results for testing null hypothesis three using ANOVA test at a 0.05 significance level are presented in Table 10.

Table 10: Summary of Analysis of Variance (ANOVA) on Achievement Scores of Experimental Groups Based on Gender

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	5301.509	3	1767.170	14.445	0.000
Within Groups	40859.746	334	122.335		
Total	46161.255	337			

Table 10 revealed that $F_{(3, 334)} = 14.445$, with p value = 0.000, since P value is less than 0.05 ($p < 0.05$), on the basis of this p value is significant. Thus, null hypothesis four is thereby rejected. Which implies that there is significant difference on mean achievement scores of male and female pre-service physics teachers taught Web-based Infographics and Web-quest integrated instructional

platforms. Furthermore, Sidak Post-hoc Analysis was carried out to locate the direction in which a significant difference exists as presented in Table 11.

Table 11: Sidak Post-hoc Analysis on Achievement Scores of Male and Female Students taught using Web-based Infographics and Web-quest integrated instructional Platforms

(I) Gender	(J) Gender	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Experimental2_Male	Experimental2_Female	3.6874	1.7570	0.200	-0.963	8.338
	Experimental1_Male	10.4414*	1.8971	0.000	5.420	15.462
	Experimental1_Female	9.1010*	1.7294	0.000	4.524	13.678
Experimental2_Female	Experimental2_Male	-3.6874	1.7570	0.200	-8.338	0.963
	Experimental1_Male	6.7541*	1.7419	0.001	2.144	11.364
	Experimental1_Female	5.4137*	1.5576	0.003	1.291	9.536
Experimental1_Male	Experimental2_Male	-10.4414*	1.8971	0.000	-15.462	-5.420
	Experimental2_Female	-6.7541*	1.7419	0.001	-11.364	-2.144
	Experimental1_Female	-1.3404	1.7141	0.967	-5.877	3.196
Experimental1_Female	Experimental2_Male	-9.1010*	1.7294	0.000	-13.678	-4.524
	Experimental2_Female	-5.4137*	1.5576	0.003	-9.536	-1.291
	Experimental1_Male	1.3404	1.7141	0.967	-3.196	5.877

Table 11 shows the Sidak Post-hoc analysis on achievement scores of male and female pre-service physics teachers exposed to web-based infographics and web-quest integrated instructional platforms. The result indicates that male and female pre=service physics teachers in the experimental group I have p – values of 0.960 which is greater than 0.05 significant level (P > 0.05). Thus, P-value > 0.05 indicate that there is no significant difference, which implies that male and female pre-service physics teachers exposed to Web-based Infographics has equal chances of high mean achievement, male and female pre-service physics teachers in the experimental group II have p – values of 0.200 which are greater than 0.05 significant level (P > 0.05). Thus, P-value > 0.05 indicate that there is no significant difference which implies that male and female pre-service physics teachers exposed to web-quest integrated has equal chances of high mean achievement.

However, achievement scores of male and female pre-service physics teachers exposed to experimental I (Web-based Infographics) and experimental (web-quest integrated) have p – value of 0.000, 0.003, 0.001 which are less than 0.05 significant level (P < 0.05). Thus, p value is significant, which implies that there are no equal chances of high mean achievement scores of male and female preservice physics teachers exposed to experimental I (Web-based Infographics) and experimental (web-quest integrated). Hence, the direction of significant difference is found between the experimental group I (Web-based Infographics - Male and Female) to the

experimental group II (web-quest integrated - Male and Female).

Research Hypothesis Four: There is no significant difference in the retention scores of Male and Female pre-service physics teachers taught with the Web-quest instruction platform.

The results for testing null hypothesis three using ANOVA test at a 0.05 significance level are presented in Table 12.

Table 12: Summary of Analysis of Variance (ANOVA) on Retention Scores of Experimental Groups at Post Posttest

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	2140.679	3	713.560	7.171	0.000
Within Groups	33232.810	334	99.499		
Total	35373.489	337			

Table 12 revealed that $F_{(3, 334)} = 7.171$, with p value = 0.000, since P value is less than 0.05 ($p < 0.05$), on the basis of this p value is significant. Thus, null hypothesis five is thereby rejected. Which implies that there is significant difference on mean retention scores of male and female pre-service physics teachers taught Web-based Infographics and Web-quest integrated instructional platforms. Furthermore, Sidak Post-hoc Analysis was carried out to locate the direction in which a significant difference exists as presented in Table 13.

Table 13: Sidak Post-hoc Analysis on Retention Scores of Male and Female Students taught using Web-based Infographics and Web-quest integrated instructional Platforms

(I) Gender	(J) Gender	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Experimental2_Male	Experimental2_Female	2.4445	1.5846	0.548	-1.749	2.4445
	Experimental1_Male	6.6961*	1.7109	0.001	2.168	6.6961*
	Experimental1_Female	5.7948*	1.5597	0.001	1.667	5.7948*
Experimental2_Female	Experimental2_Male	-2.4445	1.5846	0.548	-6.638	-2.4445
	Experimental1_Male	4.2517*	1.5709	0.042	0.094	4.2517*
	Experimental1_Female	3.3503	1.4048	0.101	-0.368	3.3503
Experimental1_Male	Experimental2_Male	-6.6961*	1.7109	0.001	-11.224	-6.6961*
	Experimental2_Female	-4.2517*	1.5709	0.042	-8.409	-4.2517*
	Experimental1_Female	-0.9014	1.5458	0.993	-4.993	-0.901
Experimental1_Female	Experimental2_Male	-5.7948*	1.5597	0.001	-9.923	-5.7948*
	Experimental2_Female	-3.3503	1.4048	0.101	-7.068	-3.3503
	Experimental1_Male	0.9014	1.5458	0.993	-3.190	0.9014

Table 13 shows the Sidak Post-hoc analysis on retention scores of male and female pre-service physics teachers exposed to web-based infographics and web-quest integrated instructional platforms. The result indicates that male

and female pre-service physics teachers in the experimental group I (web-based infographics) have p – values of 0.993 which is greater than 0.05 significant level (P > 0.05). Thus, P-value > 0.05 indicate that there is no significant difference, which implies that male and female pre-service physics teachers exposed to Web-based Infographics has equal chances of high mean retention, male and female preservice physics teachers in the experimental group II (web-quest integrated) have p – values of 0.548 which are greater than 0.05 significant level (P > 0.05). Thus, P-value > 0.05 indicate that there is no significant difference which implies that male and female pre-service physics teachers exposed to web-quest integrated has equal chances of high mean retention. More so significant difference was not found between both female of in Web-based Infographics group and web-quest integrated group.

However, achievement scores of Male-I to Male-II and Female-I to Male-II pre-service physics teachers exposed to experimental I (Web-based Infographics) and experimental (web-quest integrated) have p – value of 0.001, 0.042 which are less than 0.05 significant level (P < 0.05). Thus, p value is significant, which implies that there no equal chances of high mean achievement scores of Male-I to Male-II and Female-I to Male-II pre-service physics teachers exposed to experimental I (Web-based Infographics) and experimental (web-quest integrated). Hence, the direction of significant difference is found between the Male-(Web-based Infographics) to Male-(web-quest integrated) and Female-I (Web-based Infographics) – Male-II(web-quest integrated).

Summary of Findings

Based on the results of data analysis presented, findings revealed that;

1. There is significant difference in the mean academic achievement scores of pre-service physics teachers taught with Web-based Infographics and Web-quest integrated instructional platforms, in favour of Web-quest integrated instructional platform
2. There is significant difference in significant difference in the mean retention scores of pre-service physics teachers taught with Web-based Infographics and Web-quest integrated instructional platforms, in favour of Web-quest integrated instructional platform.
3. There is significant difference on mean achievement score of male and female pre-service physics teachers taught with Web-based Infographics and Web-quest integrated instructional platforms. Hence, the direction of significant difference is found between the experimental group I (Web-based Infographics - Male and Female) to the experimental group II (web-quest integrated - Male and Female).
4. There is significant difference on mean retention score of male and female pre-service physics teachers taught with Web-based Infographics and Web-quest integrated instructional platforms. Hence, the direction of significant difference is found between the Male- (Web-based Infographics) to Male-(web-quest integrated) and Female-I (Web-based Infographics) – Male-II(web-quest integrated).

Discussion of Results

The findings from the study underscore the effectiveness of both web-based integrated infographics and web-Quest integrated instructional platforms on learning outcomes of pre-service physics teachers among colleges of education in South-East, Nigeria. These findings align with and contribute to the existing body of literature on the use of collaborative and student-centred instructional strategies in teaching pre-service physics teachers. The findings of the study highlight significant differences in the academic achievement, retention, and interest levels of pre-service physics teachers taught using Web-based Infographics and Web-quest integrated instructional platforms. The detailed discussion of each finding is as follows:

The study revealed a significant difference in the mean academic achievement scores between pre-service physics teachers taught with Web-based Infographics and those taught with Web-quest integrated instructional platforms. The Web-quest platform proved to be more effective in enhancing the academic performance of the students. This result aligns with previous studies. Saheed et al. (2019) observed that Web-quests significantly improved secondary school biology students' understanding of cell division, a notoriously difficult topic. The study found no gender-based differences in performance, but it did note that low-scoring students particularly benefited from the Web-quest approach. This echoes the current study's finding that Web-quests are effective in addressing difficult concepts by providing students with a structured, engaging learning experience that encourages exploration and practical application of theoretical knowledge. The use of Web-quests allows learners to explore and interact with content actively, promoting deep learning, which likely contributes to higher achievement scores. Additionally, the flexibility and structure of Web-quest-based learning make it easier for students to apply theoretical knowledge in practical contexts, thus enhancing their performance. In contrast to Web-based Infographics, which tend to focus on visual summarization and simplified representation of information, Web-quests involve a structured, inquiry-based approach where students follow guided steps to explore a topic

The findings of the study also revealed that there was a significant difference in the retention scores of the pre-service physics teachers, with those taught using the Web-quest platform outperforming their peers who used Web-based Infographics. Retention, which measures how well students can recall and apply learned concepts after a period of time, is particularly strengthened by the Web-quest's interactive and explorative nature. The study by Tavanapour et al. (2022) also supports the idea that interactive, engaging platforms like Web-quests foster longer-term retention by encouraging learners to engage more deeply with the material during the learning process. Furthermore, Alebous (2021) found similar results regarding the impact of Web-quests on student retention in biology education.

The study also revealed a significant difference in academic achievement scores between male and female pre-service physics teachers in both Web-based Infographics and Web-quest integrated instructional platforms. Male and female participants responded differently to the two instructional methods. For example,

males in the Web-quest group outperformed females in the Web-based Infographics group, indicating that Web-quest-based learning may appeal more to male students, perhaps due to its exploratory nature. This is consistent with the findings of Godpower-Echie and Ihenko (2017), who identified gender differences in interest and performance in science-related subjects, though they emphasized that interest plays a significant role in determining academic success regardless of gender.

There was also a significant difference in retention scores based on gender. Males in the Web-based Infographics group performed better than their counterparts in the Web-quest integrated group, while females in the Web-based Infographics group outperformed males in the Web-quest group. This suggests that females might find Web-based Infographics more effective for retention due to its visual and structured presentation. Conversely, males may benefit more from the exploratory and task-oriented nature of Web-quests, which might enhance their ability to retain information better. Netty et al. (2020) emphasized that female students, particularly in STEM fields, often prefer instructional methods that present information in a clear and organized manner. The infographic format, with its ability to break down complex information into easily digestible chunks, aligns with the cognitive preferences of many female learners, facilitating better retention of information over time.

Conclusion

This study evaluated the effectiveness of two instructional platforms—Web-based Infographics and Web-quest integrated platforms—on the learning outcomes of pre-service physics teachers in South-East Nigeria. Through a comprehensive analysis of academic achievement, retention, and interest levels among students, the study sought to determine which method provided a more enriching educational experience. The findings indicate that both instructional strategies have their unique strengths, yet significant differences emerged in various aspects of student performance.

The finding revealed a significant difference in the mean academic achievement scores between the two instructional methods, favoring the Web-quest integrated platform. This suggests that the exploratory nature of Web-quests may provide a more effective environment for learning physics concepts. The finding also highlighted that retention scores also favored the Web-quest platform, emphasizing its potential to enhance long-term memory of the material taught. Moreover, the study uncovered significant differences in achievement and retention scores based on gender, with distinct patterns emerging for male and female participants in both instructional platforms. The findings indicate that males in the Web-quest group outperformed females in the Web-based Infographics group, while females excelled in the Web-based Infographics environment. Lastly, the interest scores reflected notable gender-specific preferences, with differences highlighted between the two groups based on the instructional method employed.

Overall, these findings contribute valuable insights into the pedagogical approaches used in teaching physics, suggesting that both Web-based Infographics and Web-quest integrated platforms offer distinct benefits that can be leveraged to enhance

educational outcomes for pre-service teachers.

Recommendations

Based on the findings of this study, the following recommendations are proposed:

1. Given the significant improvement in academic achievement and retention scores associated with Web-quest integrated instructional platforms, educational institutions should prioritize the incorporation of these platforms into their physics curricula. Training programs for educators should focus on effective implementation strategies that foster exploration and inquiry-based learning.
2. Recognizing the differences in performance and interest levels between male and female students, educators should adopt gender-responsive instructional strategies. This may include offering a mix of exploratory and structured learning experiences that cater to diverse learning preferences, ensuring that all students are adequately supported.
3. Both platforms demonstrated benefits in fostering student engagement. Educators should encourage collaborative learning opportunities within these frameworks, allowing students to work together on projects, discussions, and problem-solving activities that enhance their understanding and retention of physics concepts.

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