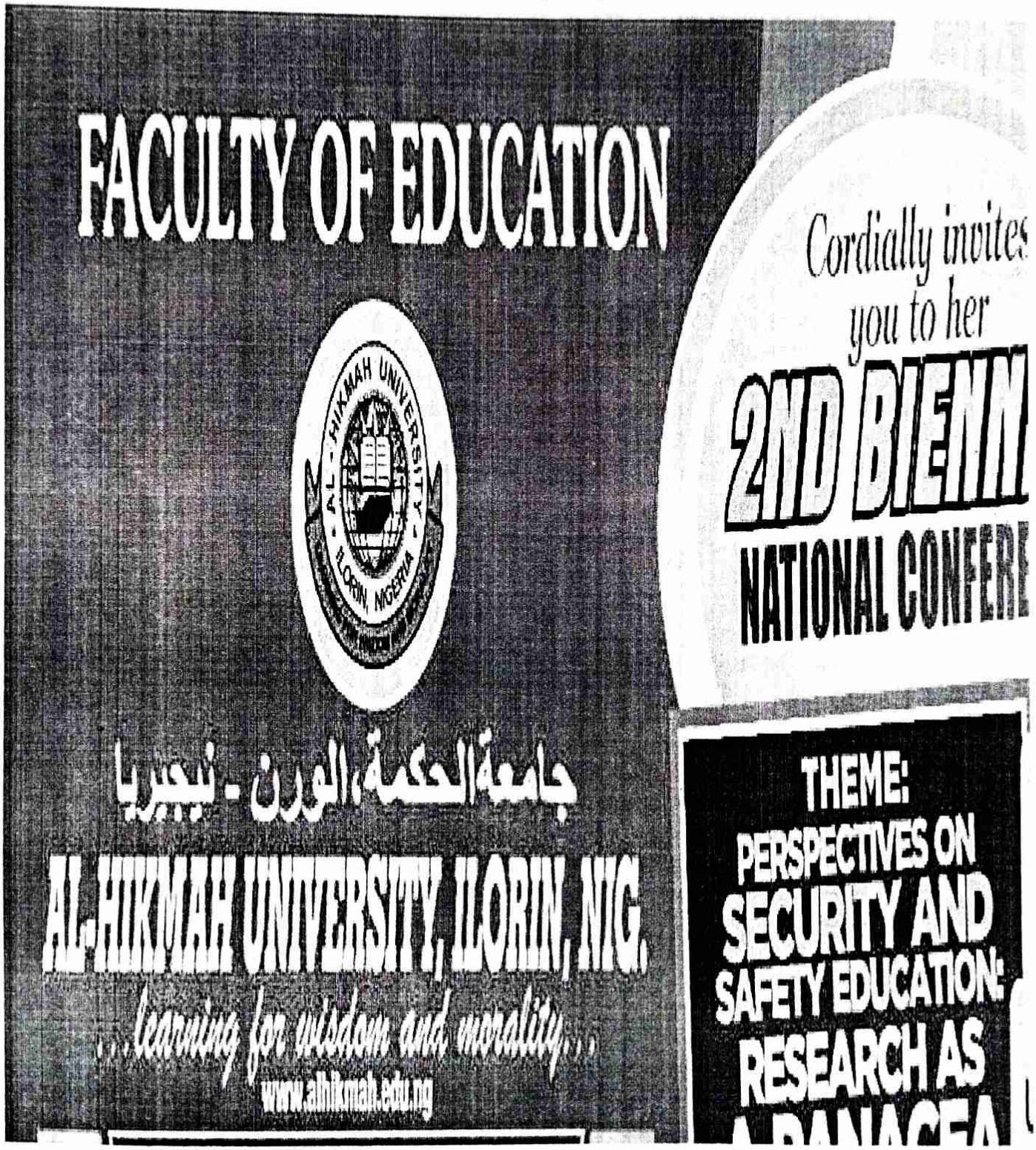

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Examining the Difference Between Marker-Based and Markerless Augmented Reality on Learning Outcomes of Biology Students' Colleges of Education in Nigeria

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Abstract

This study was carried out to examine the difference between marker-based and markerless augmented reality on learning outcomes of Biology students in Colleges of Education in Nigeria The study adopted a quasi-experimental design. (Pre-test, post-test non-equivalent control group design). Four null hypotheses guided the study with NCE I Biology students in 2020/2021 academic session comprising 326 as the sample of the study. The instruments used for data collection were the Biology Achievement Test (BAT) and Biology Retention Test (RAT) Pearson Product Moment Correlation (PPMC) formula was used to determine the reliability coefficient of BAT which yielded 0.79 and Cronbach Alpha formula was used for QMSAR which also yielded 0.85 indicating that the instruments were reliable for the study. The data was analyzed using ANCOVA to test the null hypotheses at 0.05 level of significance. Findings revealed a statistically significant difference with moderate effect size in the mean achievement, and retention scores of students taught Biology course using Marker-based and Markerless Augmented Reality in Colleges of Education in North – Central, Nigeria. Similarly, there is a significant difference with small effect size between the mean achievement scores of male and female students taught Biology course using Marker-based Augmented Reality in Colleges of Education in North – Central, Nigeria. Based on these findings, it was recommended among others that the teaching of Biology course in Colleges of Education in North – Central, Nigeria should be given attention by College administrators through the use of relevant instructional materials like marker-based and markerless augmented reality. This is to ensure that Biology students are adequately trained to face the world of work with knowledge and experience to practice and deliver services effectively.

Keywords; Achievement, Application, Augmented Reality Application, Marker-based Augmented Reality, Markerless Augmented Reality.

1.1 Background to the Study

As globalization continued to turn the world to a global village through information technologies, educational systems become dynamic and are constantly being reviewed, developed and adapted to the requirements of the time. Supporting the dynamic changes, educators had to increase the quality of educational output by integrating technologies in their teaching (Aivelo and Uitto, 2016). This is necessary because, students are not only prepared for the dynamic changes that may occur in education but are the prime movers of the change process. It is worthy to note that students being digital natives are already conversant with the landscape of technological developments; hardware, software, internet and social media sites.

Information and Communication Technology (ICT) is increasingly becoming an attractive tool for educational practitioners in the 21st century. Educators now use computers, computer networking (the Internet and intranet), peripheral devices and multimedia, and the range of assistive technologies available for students with special educational needs to facilitate programs development, management and implementation of curricular contents in a more effective way. These technology tools have the potential to augment and transform classroom learning and teaching by offering teachers and students with educational resources which extend their teaching and learning environment beyond the classroom (Sharma, 2016).

Balasubramanian and Saminathan (2016) highlighted that ICT support the aims, principles and objectives of education by way of simplifying the means to which curriculum is implemented. Notwithstanding, curriculum implementation require the creative use of ICT in education which has the capacity to increase the quality of students' learning outcome. To achieve this, teachers have to exploit the potential of ICT to complement their own pedagogical practices by making students an active agent in their own learning. Piaget (2013) clarified that "learning is an active process of constructing knowledge, rather than simply acquiring knowledge". Thus, in a technology driven environment, ICT tools promote active learning by enabling students to find, manage, evaluate and use information retrieved from CD-ROMs and websites. The process support students on their journey through construction of new knowledge in a scientifically controlled laboratory experiment, discuss findings and share their experiences with others using presentation software and social media handles. ICT are connected to the possibilities for supporting students learning differentiation through the creation of a specialized digital learning environment and the use of reinforcement software like augmented reality to prompt for image and object recognition. Thus, the sophistication of ICT has gone beyond using them for teaching, assessment and engagement with content, but for innovations related to digitization of educational practice (Aivelo and Uitto 2016).

Augmented Reality AR was first developed in 1992 by the military and was called Virtual Fixtures developed by the U.S. Air Force's (Henriksson, 2019). Akma, *et al.*, (2018) envisioned that, there is need to digitize teaching and learning by integrating augmented reality as one of the innovations that might drive impactful teaching and functional learning. It is described as a structure of tools that allows an individual to view one or more virtual objects in real world environment. AR technology makes it possible for viewing things in real environment as an imagery attached to real location and objects (Bistaman, *et al.*, 2018). AR is a term that describes the environment which combines reality and virtual with the aid of computer so that the boundary between reality and virtual became very thin. The manipulation of the virtual environment in the real environment creates a new learning environment between teachers and students. AR emerges as a technology that may help students develop their perception, learning and visualization skills and become interactive

teaching materials with a high rate of information transfer for teachers (Ali *et al.*, 2017). Augmented Reality (AR) is an interactive experience where the real world is enhanced or completed by computer-generated additions. The process works well with image recognition and scene description with narrations; that is voice, image and text jointly describe the scene of interest.

Building and using AR scenes combines active complex problem solving and teamwork to create engaging educational experiences to teach science, math or language skills, and studies have found that this activity enhances student motivation, involvement, and engagement (Sural, 2018). Furthermore, Akcayir & Akcayir, (2017) stated that AR technology has the ability to render anything that may be hardly visualized in a classroom to 3D model systematized for real-time recognition. Along with the rapid development of AR, it can now be accessed from a user's smartphone, in which the smartphone camera captures the real images and the system add necessary information about the images to the screen. AR consists of merging live images with virtual layers of information of three-dimensional (3-D) models that include content, images, sounds, and videos as instructional formats in education systems (Vogt & Shingles, 2013; Chang, *et al.*, 2016).

The AR technology supports student's seamless interaction between real and virtual environments and allows the use of a tangible interface metaphor for object manipulation (Yuliono, *et al.*, 2018). This occurs by augmenting physical devices with virtual annotations and illustrations. The digital content displayed in AR is registered in the physical world and designed to provide the user with the mixed view of reality. Categorically, the applications are generally designed to perform the functions of Marker – Based and Markerless AR in which the former uses a physical object as a trigger, as the device detects the trigger, it displays corresponding and preprogrammed digital information. While the later displays digital information based on user's specific location and is enabled by internet connectivity. In these applications, a user will view the marker and an overlay of digital information appears for the user. This digital information can include pictures, three dimensional animations, text, audio, and video (Mcmahon, 2014).

Vogt and Shingles (2013) described the differences between the two forms of AR and refer to Marker-based as an object that when viewed by the AR application will trigger preselected digital content. Examples include pictures, audio, and video that display for the user when the user views the printed trigger.

Markerless AR is location-based and displays digital information based on a user's specific location. Thus, for the trigger to be activated, internet access and GPS is required to provide accurate display of information. As such, it is called location-based AR because, it depends on GPS, compass, internet, and other tools to recognize the user's location and to display the digital content corresponding to the user's location. As the user moves the device, changes orientation, or moves themselves, the device continues to update the AR view based on the new situation (Yiu and Chen, 2021). Additionally, when these tools (AR) and resources are effectively integrated for the purpose of teaching and learning, it may simplify the identification of specimens in a science class, guide the selection of samples in the field and also motivate students.

The utilization of marker-based and markerless AR are useful in teaching Biology; in which the AR is used to build on how students interpret the real physical world. This approach has helps in the development of a special type of interactive AR application especially in the field of Biology in higher education. Therefore, educators have begun to seek classroom

technologies that have the potential to help students learn actively and may improve their understanding especially in subjects that are abstract in contents such as Biology (Morimoto and Ponton, 2021). The adoption of AR in the educational setting could be in different disciplines such as science, engineering, magnetic fields, electrical engineering laboratory for distance education and astrophysics (Vogt and Shingles, 2013; Chen, *et al.*, 2017).

In the recent times, the applications of AR system in educational setting is gaining acceptance among educators, instructional designers and researchers. This technology has been successfully integrated into many broad fields of education, achieving promising results. For instance, Almoosa (2018) identified its application in the field of Natural Sciences, Mathematics and Statistics (52.50%), Social Sciences, journalism and information (15%), Arts and Humanities (15%), and Engineering manufacturing and construction (15%). In contrast, AR is yet to gain prominence in the fields of education in Africa and Nigeria though, Kamarainen, *et al.*, (2013) reported that AR was effective in supporting situated learning in environmental science education, while Bistaman *et al.*, (2018) believes that there are many benefits of AR when integrated toward teaching and learning process.

The existence of AR in higher education is still daunting demanding for empirical investigation. Again, research in the area of AR is at the nascent stage especially in Africa specifically Nigeria. The available studies in developed countries had uncovered the significance of AR in expanding the possibilities for teaching and learning both academically and behaviorally (Akcayir and Akcayir, (2017). These authors believed that AR is such a technology that offers a new educational approach that help learners to develop capacity for critical thinking and deeper understanding of the concepts underlying scientific investigation. Also, AR makes it possible to study abstract concepts such as three-dimensional shapes and geometric objects, which are difficult to understand through a text book and conventional / lecture method or a teaching method used which involves primarily, an oral presentation given by a teacher in front of learners alone. Augmented reality merges any digital information within real-world settings to electronic information in a variety of media formats; not only visual and graphic media but also text, audio, video and tactile, it is research potential in educational settings is enormous (Chen, *et al.*, 2017; Almoosa, 2018). Lindgren and Johnson-Glenberg, (2013) suggest that these innovative technologies can bridge the "abstraction gap" between everyday experience and abstract understanding by creating a controlled context for physical interaction with content from which abstract concepts can be built.

The use of marker – based AR and markerless AR are useful in Biology contexts, where the virtual representations can be used to shape how students interpret the physical world. This approach has assisted in the development of a special type of interactive technology – based medium especially in the field of Biology in colleges of education. Biology is one of the aspects of science education. It is one of the important science subjects instructed in both secondary schools and higher institutions in Nigeria (Salami, O., Oloyede, M. A., & Adefioye, A. E., 2019). Biology is a subject that engages students in various process skills such as observation, clarifying, interpreting and predicting events, designing experiments, organizing information, and reporting adequately. One primary function of biology teaching is to help the students understand and apply biology concepts, principles, theories, and laws. Adenike, et, el (2019) observed that mastery of concepts in biology is difficult to achieve among students, and worse still, is assessing abstract concepts such as biological associations, which are prerequisites to understanding other life processes. Due to the abstract nature of the concepts of biological associations in biology, many students find these concepts difficult to

comprehend, connections to previous knowledge and to apply the concepts to real life situations. Therefore, to make Biology more relevant, enjoyable, easy and meaningful to learners, adequate relevant technologies (instructional materials) need to be provided and properly utilized as the teaching and learning situation may require.

Achievement can therefore be inferred as the behavior which a student exhibits within a given time range or at the end of a given period of time. Academic achievement in Biology is the quality and level of skills acquired and retained by students. Akor, (2017) and AL-Dulaimi (2021) noted that students' cognitive or psychomotor achievement is quantified by a measure of the student's academic standing in relation to those of other students. The purpose of testing an achievement is to help the teacher and the students evaluate and estimate the degree of success attained in learning a given concept. Achievement in Biology therefore, represents how fast the learner comprehend and retain a subject matter at a certain period of time. The degree of a student's cognitive achievement may be influenced by the ability to retain learning.

Retention is the learner's ability to recall, hold, often utilize and supply the attained knowledge or skills in the future. In other word, Adeniji, *et al.*, (2018) refer to retention as the ability to memorize and reproduce the learnt materials when the need arises. Retention of learning is the repeated performance, skill or behavior earlier acquired by a learner, elicited after an interval of time (Erbas and Demirer,_2019). Retention is influenced by proper assimilation and storage of gained knowledge or skills. The nature of student's achievement, retention in biology course especially in colleges of education is discouraging as few students graduate every academic year (Amedu, 2015; Schneider & Preckel, 2017; Köse, *et al.*, 2018). This prompted the need to investigate whether biology education students are not motivation with the current teaching methods? Reacting to this, Owino (2018) remarked that students need motivation to learn biology.

Gender is a physiological phenomenon that divides individual into various categories such as males and females with each having associated stereotypes, roles, dress etc. It is also said to be the mental analogue of sex (Dirin, 2019). However, the effect of different technological software learning approaches on gender and learning related outcomes such as academic achievement, retention and students' motivation cannot be overlooked in educational research, hence this study intends to examine the difference between marker-based and markerless augmented reality on learning outcomes of Biology students in Colleges of Education in Nigeria.

Despite the importance attached to Biology as stated in the National Policy on Education (FRN, 2009), students' academic achievement is still unsatisfactory. Following this assertion, the study projected that the teaching of Biology education course in colleges of education does not involve much use of technology but predominantly characterized by conventional teaching method. This often produce students who are less engaged, less attentive and dependent upon memorization without having a total understanding of the course. Similarly, as students failed to understand the concepts due to abstract nature of the course contents and poor motivation to continue learning, retention of the learnt material also becomes difficult. It is however, not known empirically whether gender variations influence Students learning of biology related concepts in colleges of education.

In order to avert this ugly menace and produce a productive biology education graduates, lecturers and students in colleges of education requires technological teaching and learning

devices that are based on the ability to access a variety of information sources, hands-on practical and a friendly learning environment. This implies that when tertiary institutions remain entwined with conventional teaching method and failed to explore educational technology tools and devices, it may become less relevant in producing efficient human capital which will in turn undermine national growth and economic development of the country (Franklin *et al.*, 2014; World Council for Curriculum & Instruction, 2019).

The purpose for the study is to investigate the impacts of marker-based and markerless augmented reality application on Biology student's achievement and retention in Colleges of Education in North – Central, Nigeria. More so, the result of the study is expected to provides results on Markerless AR application proving to be effective in enhancing Biology student's achievement and retention, its responsiveness to students' learning demand, adding up to their curiosity and attention to learning Biology concepts in an interactive learning medium which was not achievable with conventional learning environment and also proving to be gender responsive for favoring both male and female students.

The study was limited to examine the difference between marker-based and markerless augmented reality on learning outcomes of Biology students in Colleges of Education in Nigeria. Specifically, there are fifteen (15) Colleges of Education in the North – Central, Nigeria of both Federal and State (Benue, FCT, Kogi, Kwara, Nasarawa, Niger and Plateau) out of which four (4) Colleges of Education (Federal College of Education, Kotangora, Niger State, Nasarawa State College of Education, Akwanga, Federal Capital Territory College of Education, Zuba, Abuja and Kwara State College of Education Technical, Lafiagi) randomly selected.

1.4 Research Hypotheses

The following null hypotheses are formulated and tested at 0.05 level of significance:

HO_1: There is no significant difference in the mean achievement scores of male and female students taught biological associations using Marker-based Augmented Reality in Colleges of Education in North – Central, Nigeria?

HO_2: There is no significant difference in the mean retention scores of male and female students taught biological associations using Marker-based Augmented Reality in Colleges of Education in North – Central, Nigeria?

HO_3: There is no significant difference in the mean achievement scores of male and female students taught biological associations using Markerless Augmented Reality in Colleges of Education in North – Central, Nigeria?

HO_4: There is no significant difference in the mean retention scores of male and female students taught biological associations using Markerless Augmented Reality in Colleges of Education in North – Central, Nigeria?

2.0 Review of Related Literatures

2.1 Empirical studies on student's Achievement

Safadel and White (2019) carryout a study on Spatial understanding of molecules in molecular biology in isolation and relation to their next elements. Augmented reality (AR) was developed as a computer interface that enables the users to see the real world with virtual objects superimposed on it. Users can easily convert the molecules structures obtained from protein data bank (PDB) to a 3D format and use it with an AR application to study the molecules from different perspectives. A sample of 60 college students was assigned randomly to one of two conditions namely 2D and AR. At the end of the experiment,

participants completed a comprehensive test and then a satisfaction questionnaire. The results of the study showed a significant difference in the achievement between 2D and AR in satisfaction, the media usability, perception, and apprehension.

Yiu and Chen (2021) carryout a study on Molecular Data Visualization with Augmented Reality (AR) on Mobile Devices. The AR was a computer-generated 3D model superimposed onto a real-world environment in real time. The application of AR in visualizing macromolecular structures provide step-by-step guides on a standalone app Ollomol (iOS and Android), as well as an in-browser web app, WebAR-PDB. Both of them allow users to specify entries from the Protein Data Bank (PDB) for an elementary AR experience. The result showed that the application of AR enhances students' interactivity and imaginativity in macromolecular visualization.

Önal and Önal (2021) conducted a study to determine the effect of teaching astronomy through augmented reality (AR) on the achievement and interest level of gifted students and their opinions about AR applications. The study design was an explanatory sequential mixed-methods design. The sample comprised of 51 gifted students (26 in the control group and 25 in the experimental group) attending a Science and Arts Centre. In the application process, the astronomy teaching activities supported with AR were used in the experimental group while the astronomy teaching activities suggested in the official science curriculum of the middle school 7th grade were used. The data of the study were collected by using an Astronomy Achievement Test and the Scale of Interest in Astronomy as a pretest and posttest and an AR Interview form administered only to the experimental group students at the end of the application.

The statistical analyses of the quantitative data revealed that before the experimental application, the experimental and control groups were equal in terms of astronomy achievement and interest in astronomy. After the completion of the application, however, significant differences were found for both the experimental and control groups in favor of the posttest. Moreover, significant differences were also found in the posttest in favor of the experimental group in terms of both astronomy achievement and interest in astronomy. In other words, AR-supported astronomy teaching activities positively affected the experimental group students' astronomy achievement and interest in astronomy. Furthermore, the experimental group students expressed many positive opinions about the AR applications within the categories of technical features and cognitive and affective features. The experimental group students wanted the use of AR applications in the teaching of other science subjects and other courses.

Cakir, *et al.*, (2021) carryout a study on Integration of mobile augmented reality (MAR) applications into the 5E learning model in Biology teaching. A convergent parallel mixed research method is used. The study was conducted with the 31 preservice science teachers in a General Biology Laboratory Course in the 2018-2019 academic year. As the data collection tools, "Achievement Test with Open-Ended Questions", "Attitude Scale towards Digital Technology" and "Semi-Structured Interview Form" were used. The evaluation of the research results indicates that MAR practices in the biology laboratory have increased the academic success and positively affected the attitudes of preservice teachers towards digital technology. Moreover, preservice teachers expressed that applications of MAR facilitated their learning and understanding, making the lessons more attractive.

AL-Dulaimi (2021) carryout a study on the effect of teaching according to the augmented reality on the technique of the visual thinking skills among scientific fifth-grade students in a biology course. An experimental research approach was adopted with the partial set of two equal groups with the dimensional test of visual thinking skills. The research population represented all the scientific students of the fifth grade for morning government schools affiliated to the General Directorate of Education of Baghdad / Karkh II, alshakerin preparatory for boys was chosen intentionally, in which two groups were chosen for this study. One group is chosen randomly as the control group via lottery, whereas the other group is chosen to be as the experimental group. The total number of students are 53 students. 26 students are chosen for the experimental group that were taught according to the augmented reality technique. The other group is the control group consisting of 27 students that were taught according to the traditional way. The results showed there is statistically a significant difference for the experimental group in the visual thinking skills test.

Adedokun-Shittu, Ajani and Nuhu, (2020) carried out a study on Augmented reality instructional tool in enhancing geography learners' academic performance and retention in Osun state Nigeria. Physical Geography comprise abstractions leading to students' conceptual difficulties, leading to poor academic performance and low retention. The study engaged a visualization technology; Augmented Reality Instructional Tool (ARIT) to examine Geography learners' performance and retention when they are exposed to its' use in learning Physical Geography concepts. Four research questions were answered, while, one hypothesis was tested at 0.05 level of significance. A mixed method research approach of an experimental and survey designs was adopted. A multistage sampled intact class served as the participants. Three test instruments: an open-sourced AR mobile application (ARSJA); an adopted performance and retention test on physical geography (PRTPG); and a validated 7-Item questionnaire with a reliability value of 0.82 were employed as the research instrument. A retention rubric adopted based on Brown-Peterson Task of Memory was used as the qualitative content analysis tool. The major finding of the study was that ARIT enhances learners' performance and retention, and equally embrace gender equality. The study concluded, that the teaching and learning of Geography can be enhanced with the use of ARIT.

Çetin and Türkan, (2021) investigate the Effect of Augmented Reality based applications on achievement and attitude towards science course in distance education process. A single group pretest and posttest experimental design was used. The research group consisted of 15 third grade students attending school during the 2020–2021 academic year. In the research, AR-based applications were designed for some gains aimed at the "Electric Vehicles" theme in the science course and these applications were shown to the students through the Zoom program. The applications consist of 15 hours including pre and posttest. Research data were collected through data sets obtained from success and attitude scales given before and after the application. The findings obtained from the research show that the students' achievement and attitudes towards the science course increased significantly with Augmented Reality (AR) based applications.

2.2 Empirical studies on student's retention

Huang *et al.* (2019) carried out an exploratory study comparing AR and VR technologies with regard to their impact on learning outcomes, such as retention of science information. Specifically, the authors used two-conditions (AR vs VR) between- subjects' design to test college students' science-knowledge retention in response to both auditory and visual information presented on a Samsung S4 smartphone application. The results (N= 109)

suggest that VR is more immersive and engaging through the mechanism of spatial presence. However, AR seems to be a more effective medium for conveying auditory information through the pathway of spatial presence, possibly because of increased cognitive demands associated with immersive experiences. However, they highlighted that an important implication for design is that educational content should be integrated into visual modalities when the experience will be consumed in VR, but into auditory modalities when it will be consumed in AR.

Reeves, *et al.*, (2021). Use of augmented reality (AR) to aid bioscience education and enrich student experience. The study adopted a pretest and posttest research design with a sample of Twenty participants from the 2019-2020 cohort who currently enrolled on a level-4 biochemistry module were divided evenly into two groups using a random group Generation function hosted on virtual learning environment (Moodle). Group 1 were given 15-minutes to complete formative test comprising 13 multiple choice questions designed to test their knowledge and understanding of concepts in *Structural Biology*. After which, participants attended a 20-min AR-enhanced teaching session. The data was analyzed using t-test. The result showed that there is a move towards significance with the combination of both lectures and the AR session. Participants from both groups were invited to re-sit the formative test 4-weeks later in order to assess whether they had retained the information. Ten participants completed the re-sit attempt, which showed results comparable with those of group 2 4-weeks earlier.

Najwa (2021) carryout a study on Augmented Reality Mobile Learning Applications 'Pathogenar'. The research design was Rapid Application Development model. The results show that AR is a tool that improves idea visualization through virtual and real image components, enables students to easily map physical characteristics and helps them create mental images for further discourse. Results also show that AR not only increases motivation but also causes more contact between student-student and teacher-student interaction.

Rukmani and Vasimalairaja (2021) Explores the effectiveness of augmented reality to enhance lateral thinking of high school students. The researcher adopted the experimental method with a sample of 108 was taken for the research. Tools used include augmented reality marker-based content, lateral thinking scale developed and standardized by the researcher. The result of the research concludes that there is a significant effect of augmented reality to enhance lateral thinking and academic longevity of high school students.

2.4 Influence of gender on students' academic achievement

Amedu (2015), examined the effect of gender on the achievement of students in biology using the jigsaw method. The sample was made up of 87 students in SS1 in a secondary school. The study utilized an intact class because the study took place in a normal school term. There were 39 males and 49 females. The Biology Achievement Test (BAT) was constructed from past WAEC questions. These questions are standardized test and so were not subjected to further reliability test. The students administered the BAT as pretest, and the results were collated by gender. A t- test analysis showed that there was no significant difference between the mean scores of boys and girls. Results showed that there was a significant difference between the mean scores in favor of the males.

Dirin, *et al.*, (2019) study Gender Differences in Perceptions of Conventional Video, Virtual Reality and Augmented Reality. The study assessed the personal factors, such as gender differences, of perceiving and adopting technologies such as virtual reality (VR), augmented

reality (AR), and conventional video. The study was quantitative in which students were asked to perform experiments on VR, AR, and conventional videos. After the experiments, participants were asked to fill out a predefined survey about their emotional reactions to the experiments. The data was analyze using mean, standard deviation and t-test. The results show, unlike the prior research, that female participants were more enthusiastic about the usage of new technologies than males. The user experience of VR, AR and conventional videos triggered more positive emotions among females than males. For practitioners, the results suggest that the audio-visual technologies could engage more females than males.

Ibili & Billinghurst (2019) conducted a study on Assessing the Relationship between Cognitive Load and the Usability of a Mobile Augmented Reality Tutorial System: A Study of Gender Effects. The relationship between perceived usefulness, the perceived ease of use, and the perceived natural interaction factors and intrinsic, extraneous, germane cognitive load were investigated. In addition, the effect of gender on this relationship was investigated. The research results show that there was a strong relationship between the perceived ease of use and the extraneous load in males, and there was a strong relationship between the perceived usefulness and the intrinsic load in females. Both the perceived usefulness and the perceived ease of use had a strong relationship with the germane cognitive load. Moreover, the perceived natural interaction had a strong relationship with the perceived usefulness in females and the perceived ease of use in males.

Ruth & Lachlan (2019) carry out a study with a title Pokémon Go-ing or staying: exploring the effect of age and gender on augmented reality game player experiences in public spaces. This study examines the perceptions and usage of public spaces by different demographics of 27 augmented reality gamers. Survey research design was adopted with questionnaire as instrument for data collection. The study finds that there are several statistically significant differences between the experiences of men and women, and players of different ages playing *Pokémon Go* in public spaces in Australia, particularly in their mobility, sense of marginalization and sense of place.

Schaffernak, *et al.*, (2020) carrying out a study on the Potential Augmented Reality Application Areas for Pilot Education: An Exploratory Study. The study identify potential application areas for augmented reality (AR) in pilot education by addressing gender preferences. Like the field of engineering, the aviation industry is dominated by men. Because the aviation industry forecasts a high demand for pilots, it is highly desirable to address gender diversity and improve teaching methods in pilot education. In this study, potential application areas for AR-supported pilot training were investigated by conducting a survey with 60 pilots and flight instructors (including 12 women). Typical AR use cases were presented in videos, and the pilots reported their preferences regarding similar or other AR applications used in different parts of the flight training program. AR navigation was the use case that was most frequently preferred by both female and male pilots. The majority of pilots agreed that AR could potentially be used in theoretical instruction, pre-flight aircraft inspection, and procedure training. In addition, both gender groups showed similar preferences for various gaming concepts that make learning more interesting and engaging, such as receiving positive feedback. However, a higher percentage of women than men reported that achieving a target or receiving points to successfully finish a task and answering questions during the game were satisfying. Including a story in the game to attract attention was preferred by a higher percentage of men than women. The results of this study can be used to design AR educational concepts that support gender diversity in pilot education and other technical domains.

Urbano, *et al.*, (2021) conducted a Case Study of AR Technology and Engineering Students: Is There a Gender Gap? The study seeks to determine the factors influencing students' intention to use Augmented Reality (AR) allows a deeper understanding on how students react to the use of such technologies in their training as engineers. This study aims to identify the emotional and cognitive factors that influence the students' intention of using AR in their future professional life and to access possible gender differences. A group of about 150 undergraduate students from an Engineering and Industrial Management program had the opportunity to explore AR applications related to contents addressed in Sensors and Actuators course. A survey was designed and used with those students. Principal component analysis resulted in three components named interest, ease of use and attitude. Logistic regression analysis was conducted with these three components together with gender, as predictors of intention of using AR in later professional life. Attitude turned out to be the strongest predictor. This analysis has also shown that gender has no significant effect.

Buchner (2021) carry out a study on a title Generative learning strategy do not diminish primary students' attitudes towards augmented reality. A total of 56 primary school students participated and learned with augmented reality (AR) learning materials either in an experimental group or a control group. The experimental group learned with AR and additional learning strategies based on generative learning theory, namely, self-explanation and self-testing. The control group learned only with AR. A survey instrument was developed for the study. To analyze the data, the mean values of the individual items were first assigned to their respective scales. Gender differences were found for the accessibility subscale, with male participants considering the AR technology to be easier to access outside of the classroom too.

3.0 Methodology

This study adopted a quasi-experimental design, (pre-test, post-test non-equivalent control group design). The design entails the use of non-randomized sampling where the researcher cannot randomly assign subjects to a group, hence intact classes were used for experimental group I, II and control group respectively. Experimental groups and control group were given the pretest and posttest. The Experimental group one was exposed to Marker-based (AR), Experimental group two was exposed to Markerless (AR) while the control group was taught using conventional lecture method. The population for the study consisted of 3,152 Nigeria Certificate in Education (NCE) Biology students in North Central, Nigeria. The sample for the study was made up of 326 students 162 males and 164 female's students from three Colleges of Education in North - Central. The Colleges with common features such as equivalent, composition, facilities, exposure were sampled. The Colleges were randomly assigned to each of the experimental groups marker – based augmented reality application (MB), markerless augmented reality application (ML) and control group conventional lecture method (CLM). The instrument used in this study is Biology Achievement Test (BAT) a 50 – item covering topics in Biology used to collect data for both pre-test, post-test, retention test and Marker-based. The instrument was subjected to face and content validation by two experts from Science Education Department of Federal University of Technology, Minna. To determine the reliability of the instrument, a pilot test was conducted within the targeted population but outside the sampled schools for the study. Test re-test method of administration was used for (BAT) to NCE I Biology education students who were randomly selected for the period of two weeks interval. The result obtained from pilot test conducted was used for reliability test of the instruments. Pearson Product Moment Correlation (PPMC) formula was used to determine the reliability coefficient which yielded 0.79 indicating that

the instrument is reliable for the study. The instrument was letter administered to the two experimental groups and the control group. They were made to expose students to a new instructional environment; Marker-based Augmented Reality (MBAR), Markerless Augmented Reality (MLAR) and Conventional Lecture Method (CLM). The study lasted for 12 weeks. The data collected from this research work were statistically analyzed using descriptive and inferential statistics. The research questions were answered using Mean ($\bar{x}$) and Standard Deviation (SD) while the hypotheses were tested at 0.05 level of significance using analysis of variance (ANOVA) and analysis of covariance (ANCOVA) with the aid of computer software Statistical Package for Social Sciences (SPSS) version 23.0 was used for the analysis.

4.0 Results and Discussion

4.1. HO_1: There is no significant difference in the mean achievement scores of male and female students taught Biological associations using Marker-based Augmented Reality in Colleges of Education in North – Central, Nigeria

Table 1: ANCOVA Analysis of mean achievement scores of male and female students on the use of Marker-based Augmented Reality

Source	Sum of Squares	df	Mean Square	F-value	P-value
Corrected Model	1425.505[a]	2	712.753	6.110	.003
Intercept	126306.771	1	126306.771	1082.727	.000
Covariate (Pretest)	389.911	1	389.911	3.342	.070
*Gender	633.103	1	633.103	5.427	.022*
Error	13065.486	112	116.656		
Total	845536.000	115			
Corrected Total	14490.991	114			

a. S = Significant

Table 1. ANCOVA was run to examine the differences in the mean achievement scores of male and female students taught Biological associations using Marker-based Augmented Reality in Colleges of Education in North – Central, Nigeria. The table revealed that $F_{(1,112)} =$ 5.427, P-value = 0.022 at $P < 0.05$. The effect size revealed that there was a moderate difference between the groups, partial $^2 = .046$. Therefore, hypothesis one was rejected. This indicates that there was a significant difference in the mean achievement scores of male and female students taught Biological associations using Marker-based Augmented Reality in Colleges of Education in North – Central, Nigeria.

4.2 HO_2: There is no significant difference in the mean retention scores of male and female students taught Biological associations using Marker-based Augmented Reality in Colleges of Education in North – Central, Nigeria.

Table 2: ANCOVA Analysis of Mean Retention Scores of Male and Female Students on the use of Marker-based Augmented Reality

Source	Sum of Squares	df	Mean Square	F-value	P-value

Corrected Model	2616.807[a]	2	1308.404	5.976	.003
Intercept	11643.064	1	11643.064	53.177	.000
Covariate (Achievement)	153.124	1	153.124	.699	.405
*Gender	2614.998	1	2614.998	11.943	.001*
Error	24522.323	112	218.949		
Total	915940.000	115			
Corrected Total	27139.130	114			

S = Significant

Table 2: ANCOVA statistic was computed to examine the differences in the mean retention scores of male and female students taught Biological associations using Marker-based Augmented Reality in Colleges of Education in North – Central, Nigeria. The table revealed that $F_{(1,112)} = 11.943$, P-value = 0.001 at $P < 0.05$. The effect size revealed that there was a moderate difference between the groups, partial $\eta^2 = .096$. Therefore, hypothesis two was rejected. This indicates that there was a significant difference in the mean retention scores of male and female students taught Biological associations using Marker-based Augmented Reality in Colleges of Education in North – Central, Nigeria.

4.4 HO_3: There is no significant difference in the mean achievement scores of male and female students taught Biological associations using Markerless Augmented Reality in Colleges of Education in North – Central, Nigeria.

Table 3: ANCOVA Analysis of mean achievement scores of male and female students on the use of Markerless Augmented Reality

Source	Sum of Squares	df	Mean Square	F-value	P-value
Corrected Model	5654.541[a]	2	2827.270	15.971	.000
Intercept	105279.044	1	105279.044	594.708	.000
Covariate (Pretest)	244.098	1	244.098	1.379	.243
*Gender	5450.139	1	5450.139	30.787	.000
Error	18941.832	107	177.026		
Total	749063.000	110			
Corrected Total	24596.373	109			

S = Significant

Table 3: ANCOVA was run to examine the differences in the mean achievement scores of male and female students taught Biological associations using Markerless Augmented Reality in Colleges of Education in North – Central, Nigeria. The table revealed that $F_{(1,107)} = 30.787$, P-value = 0.000 at $P < 0.05$. The effect size revealed that there was a moderate difference between the groups, partial $\eta^2 = .223$. Therefore, hypothesis three was rejected. This indicates that there was a significant difference in the mean achievement scores of male and female students taught Biological associations using Markerless Augmented Reality in Colleges of Education in North – Central, Nigeria.

4.5. HO_4: There is no significant difference in the mean retention scores of male and female students taught Biological associations using Markerless Augmented Reality in Colleges of Education in North – Central, Nigeria.

Table 4: ANCOVA Analysis of Mean Retention Scores of Male and Female Students on the use of Markerless Augmented Reality

Source	Sum of Squares	df	Mean Square	F-value	P-value
Corrected Model	25543.982[a]	2	12771.991	59.863	.000
Intercept	26757.246	1	26757.246	125.412	.000
Covariate (Achievement)	1035.044	1	1035.044	4.851	.030
*Gender	23518.021	1	23518.021	110.230	.000
Error	22828.891	107	213.354		
Total	706428.000	110			
Corrected Total	48372.873	109			

S = Significant

Table 4: ANCOVA statistic was computed to examine the differences in the mean retention scores of male and female students taught Biological associations using Markerless Augmented Reality in Colleges of Education in North – Central, Nigeria. The table revealed that $F_{(1,107)} = 110.230$, P-value = 0.000 at $P < 0.05$. The effect size revealed that there was a large difference between the groups, partial $\eta^2 = .507$. Therefore, hypothesis four was rejected. This indicates that there was a significant difference in the mean retention scores of male and female students taught Biological associations using Markerless Augmented Reality in Colleges of Education in North – Central, Nigeria.

4.7. Discussion of Findings

The finding of the null hypothesis one indicated that the difference in their mean achievement scores was significant with small effect size. The finding was supported by Schaffernak, *et al.*, (2020) whose finding revealed a higher percentage of women than men reported that achieving a target or receiving points to successfully finish a task and answering questions during the game were satisfying. Similarly, the finding of Buchner (2021) also revealed that gender differences were found for the accessibility subscale, with male participants considering the AR technology to be easier to access outside of the classroom too. Finding from null hypothesis two indicates that the difference in the mean retention scores of students was statistically significant. The finding was supported by Dirin, *et al.*, (2019) whose finding showed that female participants were more enthusiastic and retentive about the usage of new technologies than males. The user experience of VR, AR and conventional videos triggered more positive emotions among females than males. For practitioners, the results showed that the audio-visual technologies could engage more females than males. Furthermore, the finding of the null hypothesis three indicates that the difference in their mean achievement scores was statistically significant with moderate effect size favoring male students. The finding is not supported by Rukmani and Vasimalairaja (2021) who revealed that there is a significant effect of augmented reality to enhance lateral thinking and academic longevity of high school students in both genders. The finding of the null hypothesis four indicated that the difference in the mean retention scores of students was statistically significant with large effect size favoring female students. The finding was not supported by the finding of Reeves, *et al.*, (2021) who showed that there is a move towards significance with the combination of both lectures and the AR session among genders. However, the finding agreed with the finding of Yiu and Chen (2021) who showed that the application of AR enhances students' interactivity, remembrance and imaginability in macromolecular visualization.

5.0 CONCLUSION AND RECOMMENDATIONS

Based on the findings of the study, Marker-based augmented reality application proved to be effective in enhancing Biology students learning outcome in Colleges of Education in North – Central, Nigeria. The superiority of marker-based was not only responsive to students' learning demand, but has added to their curiosity and attention to learning Biology concepts in an interactive learning medium which was difficult to achieved with traditional learning environment. Markerless augmented reality application was also responsive to students sensorimotor learning demand and had increased the learning outcome of students higher than the conventional lecture method group. It is therefore effective in enhancing learning however, suffer some limitations like the need for Global Positioning System (GPS) and WiFi positioning system connectivity. Though, the interactivity and the display of animations, image capture systems and triggers are all the same with marker-based but being location inclined make it fall behind its counterpart.The marker-based and markerless augmented reality proved to be gender responsive favoring both male and female students. The differences observed the in their achievement and retention is not considerable to spur attention.

5.2 Recommendations

Based on the findings and conclusions of the study, the following recommendations were made;

1. The teaching of Biology course in Colleges of Education in North – Central, Nigeria should be given attention by College administrators through the use of relevant instructional materials like marker-based and markerless augmented reality. This is to ensure that Biology graduates are adequately trained to face the world of work with knowledge and experience to practice and deliver services effectively.
2. The Federal Ministry of Education should endeavor to stimulate the production of marker-based and markerless augmented reality in order to explore its potential in Colleges of Education in Nigeria. Their use would not only increase students' achievement but motivate students to retain concepts which were ordinarily difficult to do so without the use of AR.
3. Building on students' use of mobile devices in campuses of higher learning, augmented reality applications should be installed on students' devices loaded with Biology concepts based on the course requirements by the ICT unit of the Department. This is to prepare the mind of students regarding the concepts to be treated as advance organizer to increase their achievement or as follow up review after the completion of the course to increase chances for knowledge retention.

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