Chapter One

Introduction

1.1 Background to the Study

Science is the process of learning through observation, experimentation, investigation, and conclusion-making, it is a structured approach to exploring the natural world by means of observation and experimentation. It includes developing hypotheses, performing experiments to evaluate those hypotheses, and examining the outcomes to reach conclusion. Its primary aim is to comprehend how things function, reveal the principles that govern the universe and utilize this understanding to address issues and enhance life. It covers a range of disciplines such as Physics, Chemistry, Biology and earth sciences. Education serves as the method through which individuals obtain scientific and technological knowledge, making it an essential element for all types of development while Science Education is the process by which knowledge about science and technology is obtained; hence it is an essential part of all forms of development[1]. In fact, one cannot overstate the importance of science education to the advancement of a country[2]. The study of living things, including their physical makeup, chemical reactions, molecular interactions, physiological systems, development, and evolution, is the focus of the natural science field of Biology. This subject requires students to use a variety of process skills, including observation, explanation, interpretation, event prediction, experimentation, information organization, and appropriate reporting. The goal of Biology education is to provide people with the creative skills they need to contribute to society. Every element of

daily existence is influenced by Biology. Humans depend on living things and their products for their fuel, medicine, housing, food, and personal hygiene[3].

Biology has a critical role in the growth of the national economy, and its significance cannot be overstated. In a similar vein, understanding Biology gives answers to potentially fatal problems with growth, health, and the environment. The idea makes a significant contribution to the country's technological advancement. Additionally, the notions aid in the students' understanding of laws, theories, and principles. It is a prerequisite and required subject in many academic disciplines. Its significance for a country's development cannot be overstated as a result. In the same vein, the National Policy on Education identifies some important objectives for Biology education and learning, which include: the capacity to learn practical skills and projects; the ability to acquire scientific processes and skills, such as observation, classification, and interpretation; the capacity to acquire scientific attitudes for problem solving, such as curiosity, skepticism, open-mindedness, and objectivity; the capacity to apply biological principles to real-world situations; the establishment of a foundation for future careers in fields like medicine, nursing, botany, zoology, and agriculture, among others; and the consciousness of the natural world around them[3,4,5].

Genetics is the branch of Biology that focuses on the study of genes, heredity, and genetic variation in living organisms. It encompasses a wide range of topics, from the molecular mechanisms of inheritance to the genetic basis of traits and diseases[6]. Genetic variation refers to the differences in DNA sequences among individuals within a population or species. Genetic variation arises from mutations, genetic recombination, and gene flow, and it is the basis for biodiversity and evolutionary

change[7,8].Mendelian genetics, named after the scientist Gregor Mendel, describes the inheritance of traits according to specific patterns of gene transmission. Mendel's laws of inheritance, including the law of segregation and the law of independent assortment, form the foundation of classical genetics[9,10].

Genetic crosses involve breeding experiments in which organisms with known genotypes are crossed to study the inheritance of specific traits. Punnett squares and other genetic tools are used to predict the outcomes of genetic crosses and analyze patterns of inheritance. Genetic disorders are conditions caused by mutations or abnormalities in genes or chromosomes. Examples of genetic disorders include cystic fibrosis, sickle cell anemia, Huntington's disease, and Down syndrome. Genetic engineering is the manipulation of an organism's genetic material using biotechnology techniques. It involves techniques such as gene cloning, recombinant DNA technology, and gene editing (e.g., CRISPR-Cas9) to modify genes for various purposes, such as medical research, agriculture, and biotechnology. Population genetics is the study of genetic variation and evolution within populations. It examines factors such as allele frequencies, genetic drift, gene flow, natural selection, and genetic adaptation to understand how populations change over time. Human genetics focuses on the study of genetic variation and inheritance in humans. It investigates the genetic basis of human traits, diseases, and behaviors, as well as the genetic factors influencing population diversity and ancestry. Genetics plays a crucial role in understanding the mechanisms of inheritance, evolution, and disease, and it has applications in various fields, including medicine, Agriculture, forensic science, and conservation Biology[6,7,11].

In disciplines like agriculture, where selective breeding is used to enhance desirable features in crops and livestock, genetics provides a fundamental understanding of how traits and characteristics are passed down from one generation to the next. Genetic research has led to medical advancements such as the identification of genetic abnormalities, the creation of gene treatments, and customized medicine. Knowing a patient's genetic makeup can assist in tailoring therapies that are more successful and have fewer negative effects. Genetics gives information about the mechanisms of evolution. Scientists can gain insight into how organisms adapt to their surroundings over time by researching genetic variations. In forensics, genetic profiling is performed to identify people using their DNA. This technique is critical for criminal investigations and paternity testing. Conservation biology relies heavily on genetics. It facilitates the comprehension of genetic variety within species, which is essential for preserving robust populations and formulating well-informed conservation strategy decisions.

Genetic engineering and biotechnology advancements have enabled the development of genetically modified organisms (GMOs). These can result in greater yields, insect resistance, and higher nutritional content.

Academic achievement is the successful completion of learning objectives, subject-matter mastery, and the application of abilities and knowledge in educational settings. It includes a variety of academic metrics, such as grades, test results, course completion, and academic achievement across a range of topics or specializations. Grades are frequently used as measures of academic achievement since they show how well students performed on tests, projects, assignments, and other evaluations.

Grade Point Average (GPA), which is determined by averaging a student's grades over several courses or semesters, is a numerical measure of a student's overall academic performance.

Quantitative indicators of students' academic ability in particular courses or areas are provided by test results on standardized assessments, such as standardized achievement tests, state-mandated assessments, and college admission examinations (SAT, ACT). These tests assist in determining how well students have mastered the curriculum's requirements and in comparing their results to those of other countries or regions[12, 13].

Completing coursework successfully and accumulating credits towards graduation or academic progress are examples of academic achievement. Course completion shows how well students can follow through on their education and fulfills criteria; credit accumulation, on the other hand, shows how many units or credits they have accrued towards a degree. Academic achievement is proving one's ability in fundamental subjects like Science, Mathematics, Language Arts, Social Studies, and the Arts, as well as subject matter mastery. This entails learning the fundamentals, comprehending ideas and concepts, and using analytical, critical thinking, and problem-solving abilities[14, 15].

The development of critical thinking, analytical reasoning, and problem-solving abilities is a component of academic achievement and is necessary for both academic success and lifetime learning. These abilities help students analyze data, decide wisely, and work through challenging issues in a variety of subject areas. Academic performance encompasses both written and spoken communication skills,

such as the capacity to clearly clarify concepts, coherently express ideas, and interact with others in a productive manner. Proficiency in writing and communication are crucial for achieving success in any field of study and are highly regarded in both higher education and the professional world[16].

Year after year, student performance has been unstable, especially in the field of Biology, in the Secondary School Certificate Examinations (SSCE), which is administered by the West African Examinations Council (WAEC) and the National Examination Council (NECO). Even though Biology is important to people and inventive for a nation's technological growth, the performance of candidates in the subject area is not encouraging as it is not stable and consistent. For instance, In the year 2019,the performance of students in Biology is said to have a raw mean score of 31, and standard deviation of 9.43 which was slightly better than that of WASSCE for School Candidates in 2018 with a raw mean score of 31 and standard deviation of 9.00, In 2022, the performance of candidate with a raw mean score of 37 and standard deviation of 9.54 was worse than that of WASSCE for School candidate in 2021 with a raw mean score of 40 and standard deviation of 10.00 and lastly in the year 2023, it was observed that the performance of candidate with a raw mean score of 31 and standard deviation of 10.91 was more worrisome than that of WASSCE for school candidates in 2022 with a raw mean score of 37 and standard deviation of 9.54. Oyo State got the lowest WAEC results in the Southwest with only 19% passing in 2019. The West Africa Examination Council (WAEC) data that was accessible showed that Biology had the lowest achievement among the science subjects. Students'

persistently poor academic achievement in Biology has been partially attributed to the concept of Genetics taught in secondary school[17].

Subsequently, The WAEC Chief Examiner's report on Biology questions in paper 2 indicated that among the Biology questions, genetics questions were unpopular among the candidates and very few candidates attempted them, it was reported that those who attempted them did not respond well to the questions and did poorly (2019-2023) for instance in 2019 examination, the genetics questions required the candidates to identify through the information given the genotype and phenotypic ratio of the offspring, many of them could not identify the parents as Hb which was given as symbol for the genotype of the parents and should have been used for the gametes and the off springs which made them loose marks. It was also observed that candidate failed to put the cross X sign between the parental genotypes; some even failed to cross the gamete appropriately of which all these accounted for huge loses of marks. In 2021, genetic questions asked was about candidate to briefly explain the process of gene replication in living things, it was observed by the Chief Examiners report that the question was the least answered among the candidates. Some of them could not explain gene replication in living things. In 2022, the genetic question asked the candidates to give correct punnett squares of dyhybrid cross, write number of offspring that will have required phenotypic characters, it was observed that, many candidate could not give the correct Parental Gamete Horizontal(PGH) and Parental Game Vertical(PGV) thereby getting wrong answers in offspring(F1) in the Punnette square. Also, most candidates wrote 9:3:3:1 or 1:3:3:9 as the number of offspring that will have the required phenotypic characters. Additionally, it was researched at the

post-secondary level of education in the fields of science, medicine, and related fields. Even though genetics is a significant topic, reports suggested that science students find the topic challenging and intimidating. They think it is one of the most complicated parts of Biology, thus they frequently have misconceptions and have trouble understanding its concepts, of which there is a need for teachers to lay more emphasis on the topic Genetics[18].

Studies have linked the abstract nature of genetics in Biology to its complexity, which has led to fewer students enrolling in genetics or related disciplines than in other non-STEM (*Science, Technology, Engineering and Mathematics*) fields. The difficulties in learning genetics are linked to a number of factors, such as its placement late in the Biology curriculum, inadequate or nonexistent science laboratories, non-STEM teachers teaching Biology classes, ineffective teaching methods, and a lack of contemporary instructional technologies specifically designed for teaching genetics. Many teaching techniques, such as the use of metaphorical instruction, logical prose and concept mapping, learning cycles, multimedia genetics self-learning materials, expository techniques, and annotated drawings, have been suggested as solutions to this issue. Additional recommendations include concept mapping and problem-solving techniques, video games, multimedia tools, and design criteria procedures. The potential application of modern technologies, such as digital learning platform, for genetics education has however, received little limited attention[18].

Gender and education are interconnected in complex ways, with gender influencing individuals' access to educational opportunities, experiences within educational

systems, and outcomes in terms of academic achievement and career trajectories. Gender disparities in education persist globally, despite progress in increasing access to education for girls and women in recent decades. Gender inequality in education manifests in disparities in access to schooling, enrollment rates, and retention rates based on gender. Historically, girls and women have faced greater barriers to accessing education, including cultural norms, poverty, early marriage, care giving responsibilities, lack of infrastructure, and gender-based violence. While significant progress has been made in increasing girls' access to education globally, disparities persist, particularly in regions with entrenched gender norms and socio economic inequalities. Gender differences in academic achievement and performance vary across subjects, grade levels, and contexts. While girls often outperform boys in literacy and language-related subjects, boys may outperform girls in mathematics and science, reflecting societal stereotypes and expectations about gender and academic abilities. [19, 20, 21.]

Digital learning platforms have grown in popularity in the educational sector with a variety of features to improve teaching and learning. An effort to make the process of creating, assigning, and grading assignments easier for educators, Google created a free online tool; a learning management system that offers communication, evaluation, and course administration capabilities for online education. A powerful, secure, and integrated system for creating customized learning environments that is open-source and intended for use by educators, administrators, and students. A virtual learning environment and course administration system are offered by this learning management system. Users can produce, organize, and share academic information

using a social networking site and learning management system. Teachers may develop and share information, manage assignments, and interact with students and parents using this social learning platform; an interactive teaching tool that lets instructors make and present multimedia presentations, tests, surveys, and other interactive exercises; an application for digital portfolios that enables students to produce, distribute, and consider their learning through multi-media uploads. These platforms enable educators and learners in the digital learning environment by providing a variety of features such content development, assignment administration, communication tools, assessment alternatives, and analytics[22].

Google Applications for Education (GAFE) is an effective cloud computing solution that functions independently of students' time, location, or even device type. It improves education by providing free and simple-to-use learning resources. These programmes have demonstrated their value as a teaching and learning aid that can promote cooperation, evaluate student performance and written work with ease, and give students clear instructions on how to perform at their best. Additionally, by utilizing key Google products such as Google Classroom, Google Meet, and Google Forms; students will be able to work together more effectively, become more competent, save money, and have a smaller environmental impact without compromising security or privacy. Educational technology, like Google Apps for Education, can play a significant role in helping to determine the best ways to modify teaching strategies so that students perform better academically. In order to create a successful classroom in the twenty-first century and to prepare students for success in their future occupations, technology in education must be implemented

appropriately[4].In order to educate effectively, a teacher must engage with students in the classroom, model the subject matter, and use all three of these factors. It is well acknowledged that for generations, secondary education in Nigeria has predominantly relied on traditional methods of instruction that involve face-to-face interactions in a physical classroom. With the emergence of the new coronavirus in 2020, technology-oriented learning has become essential. Teachers must use a digital teaching mode in order to accomplish efficacy in the teaching and learning of science in general and Biology in particular in this digital age[22].

Flipped Classroom Instruction using Google Classroom (FCIVGC) is one such technique. In 2012, Jonathan and Aaron invented the Flipped Classroom, a Blended Learning Model that uses digital tools to integrate online and in-person instruction. By presenting instruction as audio, video, narrations, text, and graphics, FCIVGC is a multimedia cognitive instructional mode that focuses on the cognitive processes that students used to learn. It considers the students mind as a dual channel, limited capacity, and active processing system. since students study the material at home and practice applying it in class, in order for the learner to actively create meaningful relationships between instructions in both classrooms and online. Teachers can record lectures that focus on certain curriculum subjects to meet learning objectives, which is an added benefit. In addition, it creates an existing library for students to review and complete assignments, and it permits them to pause, rewind, and review. This contrasts with the traditional instructional techniques that only require physical classroom instruction, which results in teaching in a real

classroom. The teacher does everything in the classroom, including writing and speaking[23].

Since secondary education in Nigeria has predominantly relied on traditional methods of instruction that involve face-to-face interactions in a physical classroom and application of digital learning platform received little to no attention to enhance academic achievement of senior secondary school students' academic achievement in genetics education[3,5]. This study "Effects of Digital Learning Platforms on Senior Secondary School Students' Academic Achievement in Genetics" determined the students' persistently poor academic achievement in Biology which has been partially attributed to the concept of genetics taught in secondary school.

1.2 Statement of the Problem

Genetics concept equips students with relevant knowledge and necessary skills to apply genetics principles to their day–to-day activities in order to make right decision. However, reports have shown that students have poor comprehension of the concept taught at secondary school level. Literature has attributed this to factors such as non mastery of the topic, poor attitude to Genetics, non availability of multimedia instructional materials, lack of interest from the teachers and students, poor teaching methods, individual differences, complexity and abstract nature of the topic. Different interventions have been adopted in order to improve the Academic Achievements in Genetics using various strategies such as constructive controversy, simulation, among others and yet these low achievements still persist. It is imperative to investigate alternative teaching strategies that foster student engagement, interest, creation of ideas, and knowledge construction during the learning process, and potentially

improve academic achievements. Therefore, this study is to determine the effects of Digital Learning Platforms and gender on Senior Secondary School Students' Academic Achievement in Genetics.

1.3 Aim and Objectives of the Study

The aim of this study was to determine effects of digital learning platforms on senior secondary school students' academic achievement in Genetics.

The objectives were to:

i. determine the main effect of Treatment (flipped-Google Classroom with collaborative learning approach, Flipped-Google Classroom without collaborative learning approach) on senior secondary school students' academic achievement in Genetics.

ii. examine the main effect of gender on senior secondary school students' academic achievement in Genetics.

iii. examine the interaction effect of Treatment (Flipped-Google Classroom with collaborative learning approach , Flipped Google Classroom without collaborative learning approach) and gender on senior secondary school students' academic achievement in Genetics.

1.4 Hypotheses

The following null hypotheses were tested at the 0.05 level of significance based on the stated objectives:

$H_0$1: There will be no significant main effect of treatment (Flipped-Google Classroom with collaborative learning approach, Flipped-Google Classroom

without collaborative learning approach) on senior secondary school students' academic achievement in Genetics.

$H_0$2: There will be no significant main effect of gender on senior secondary school students' academic achievement in Genetics.

$H_0$3: There will be no significant interaction effect of treatment (flipped-Google Classroom with collaborative learning approach, flipped Google Classroom without collaborative learning approach) and gender on senior secondary school students' academic achievement in Genetics.

1.5 Significance of the study

The increasing adoption of digital learning platforms in education, especially in science subjects like Genetics, has introduced new possibilities for enhancing students' academic achievement. This study on the effect of digital learning platforms on senior secondary school students' academic performance in Genetics is significant to a wide range of educational stakeholders, including policymakers, educators, curriculum developers, students, parents, and researchers. Below is an exploration of the potential benefits and implications for each stakeholder group.

For policymakers, this study provides valuable insights into how digital learning platforms can bridge gaps in science education, specifically in the specialized field of Genetics. By understanding the impact of digital learning, policymakers can make more informed decisions on resource allocation, digital infrastructure development, and funding. If the findings demonstrate that digital platforms significantly improve academic outcomes, this study would support the implementation of national policies

that integrate digital learning tools into science curricula, ultimately raising the quality of education.

School administrators are pivotal in adopting and implementing digital tools. The study's findings will inform these administrators on the effectiveness of digital platforms in improving students' understanding of Genetics and help them justify investments in technology. This study would highlight specific digital tools that enhance comprehension and engagement, leading to increased academic performance. It would provide a framework for schools to adopt appropriate platforms, encourage professional development for teachers, and potentially revise timetables and learning schedules to incorporate blended learning strategies.

For teachers, the study highlights the role digital platforms can play in facilitating interactive and student-centered learning. Understanding how digital tools affect students' grasp of complex topics, such as Genetics, enables teachers to adapt their instructional approaches to better meet student needs. Additionally, curriculum developers can use the findings to tailor digital learning resources to the Genetics syllabus, ensuring that digital tools align with educational goals and competencies. As a result, teachers can implement more engaging, relevant, and structured Genetics curricula, creating a more effective and enjoyable learning experience.

Students stand to benefit directly from the study, as it addresses how digital learning platforms influence their academic success in Genetics. By examining factors such as user engagement, ease of access, and the variety of interactive resources, the study sheds light on how digital tools can make complex genetic concepts more comprehensible. If digital learning platforms are shown to improve learning outcomes,

students may experience higher engagement, improved retention, and greater motivation, leading to increased academic achievement and an enhanced interest in the sciences.

Parents play a crucial role in their children's educational journeys, often providing the resources necessary for digital learning. This study would help parents understand the potential academic benefits of digital learning tools and justify the investment in digital devices or internet connectivity. Knowledge of these benefits can also encourage parents to support digital learning outside of the classroom, providing a conducive environment for their children to continue learning Genetics and other subjects at home.

For researchers, this study provides a foundation for further exploration of digital learning in the context of secondary school science education. The findings would inspire additional studies on specific digital tools or methodologies that maximize learning outcomes in Genetics and other science disciplines. Researchers would use the results to explore new digital pedagogies, develop innovative educational technologies, or study the impact of such technologies across various subjects, age groups, or learning environments. Furthermore, it will contribute to the growing body of literature on digital learning, paving the way for continuous improvements in educational technology.

Developers of educational technology can use the findings to improve digital learning platforms based on the needs and preferences of students and educators. Insights into the aspects of digital learning platforms that enhance academic achievement in Genetics can guide developers in creating content that is engaging, accessible, and

aligned with curriculum standards. This feedback loop between educational research and product development may result in improved tools that cater more effectively to the cognitive and pedagogical demands of complex science topics.

Finally, this study holds broader implications for society. By improving the educational attainment of students in Genetics, a subject foundational to various fields in science, technology, and healthcare, this research indirectly contributes to developing a more scientifically literate and skilled population. A generation of students well-versed in genetics concepts can better participate in health-related, environmental, and technological advancements. This knowledge can also foster critical thinking and informed decision-making on genetic and ethical issues, ultimately promoting a more knowledgeable society capable of addressing complex global challenges.

This study on the effects of digital learning platforms on senior secondary school students' academic achievement in Genetics is critical for supporting evidence-based educational strategies. By demonstrating the potential of digital platforms to enhance learning, the study can drive significant changes in policy, curriculum design, teaching methodologies, and technology development. It would also empower students and parents to fully utilize digital resources, ensuring a more enriched, effective, and forward-looking educational landscape.

1.6 Scope of the Study

The study was delimited to senior secondary school 2 (SS2) biology students in Ibadan North Local Government Area, Ibadan, Oyo State, Nigeria. This study determined the effects of digital learning platforms (flipped-google classroom with

collaborative learning approach, flipped google classroom without collaborative) on the academic achievement of Senior Secondary School Students in Genetics. The contents covered were Basic genetic Concepts, Mendelians law of Genetics, Structure of Chromosomes, and Probability in Genetics, Variation and Application of Variation.

Limitation of the Study

The constraints encountered, while carrying out this study were as follows:

Limited access to student contact information: Some schools were unable to release the phone numbers of their students, making it difficult to reach them.

Technological constraints: Some participants experienced challenges due to lack of power supply, network issues, and limited access to personal phones.

Scheduling conflicts: Classes had to be scheduled at night to accommodate students who used their parents' phones, which may not be ideal for all participants.

Limited resources: The researcher had to make provisions for equipments (laptops, generating set, and projector) and transport them daily, which may have been inconvenient and costly.

Restrictions on data collection: Schools did not allow the use of their ICT rooms for physical classes, which may have limited the scope of data collection.

1.8 Operational Definitions of Terms

The key concepts used in this study and their operational meanings were as follows:

Academic Achievement in Genetics: These are the scores of Genetics in Biology Achievement Test (GBAT) administered on the participants during the course of this study.

Digital Learning Platforms: This is a blended learning platforms used in this study as a treatment that involves technology. Such as: Flipped classroom instruction using Google Classroom.

Google Classroom: This is digital platforms adopted as online teaching strategy in this study.

Flipped Classroom: This is teaching method used in this study that allows students to learn out of the school through giving of assignments.

Genetics: This is a topic in Biology that the study covers genes, heredity, and genetic variation in living organisms with selected teaching strategies.

Gender: These are senior secondary school male and female students in the study.

Flipped Google Classroom with Collaborative Learning Approach: it is a kind of learning approach that involves grouping the students and giving a task to do from home via Google classroom

Flipped Google Classroom without Collaborative Learning Approach: it is a kind of learning approach that does not involves grouping the students but giving individual task to do from home via Google classroom

Conventional Method: This is the traditional method of teaching that is teacher centered

Endnotes

1. N. E. Nnodim & A. U. Nwanekezi, *Enhancing Students' Performance in Genetics using 5e Learning Cycle and Web quest in Secondary Schools in Rivers state,*

International Journal of Multidisciplinary Education and Research, 8(2), 2023, 1-5.

2. E. A. Ayimbila& D. Akantagriwon, *Effect of Concept Mapping Instructional Strategy Accompanied by Discussion Web on Students' Academic Achievement in the Concept of Genetics,***Journal of Education and Practice,** 5(3), 2021, 1 – 16.

3. S. T. Mkimbili, *Do Biology Syllabi Provide Opportunities for Secondary School Students to Engage with Critical Thinking Skills?,***Journal of Biological Education**, 58(2), 2022, 444–459. Available online: https://doi.org/10.1080/00219266.2022.2067582.

4. M. F. Schneider, *Living Systems Approached from Physical Principles,***Progress in Biophysics and Molecular Biology** 162, 2021, 2–25. Available online: https://doi.org/10.1016/j.pbiomolbio.2020.10.001.

5. S. Dominik, & T. Weil, *Chemical Reactions in Living Systems,***Advanced Science**, 11(8), 2023, Available online: https://doi.org/10.1002/advs.202303396.

6. T. Teker, G. Albayrak, T. Akayli& C. Urku, *Screening of Lactococcal Adhesion Genes and Two Pneumococcal Genes as Genetic Determinants of Virulence in LactococcusGarvieae Strains,***Genetics of Aquatic Organisms,** 4(2), 2020, 61–67. Available online: https://doi.org/10.4194/2459-1831-v4_2_01.

7. N. U. Saher, F. Naz, & M. Kamal, *Mitochondrial DNA Variation and Population Genetic Structure of Mud Crab, Scylla Serrata from Pakistan/Northern Arabian Sea,***Genetics of Aquatic Organisms,**3(2), 2020,67-77. Available online: https://doi.org/10.4194/2459-1831-v3_2_04.

8. A. K. Webster & C. P. Patrick, *Heritable Epigenetic Variation Facilitates Long-Term Maintenance of Epigenetic and Genetic Variation*, **Edited by IKronholm. G3: Genes, Genomes, Genetics** 14(2), 2023, 1-15Available online: https://doi.org/10.1093/g3journal/jkad287.

9. E. Matalova, *Johann Gregor Mendel: Born to Be a Scientist?***PLOS Biology**, 20(7), 2022, e3001703. Available online: https://doi.org/10.1371/journal.pbio.3001703.

10. M. C. Jeffrey, L. C. Robin, A. W. Tawny, H. Lexie, L. Madison, J. Wilson, & D. Harrison, *Revisiting Mendel: Use of a Behavioral Assay to Examine Inheritance of Traits in Drosophila,* **Advances in Biology Laboratory Education**, 42, 2022. Available online: https://doi.org/10.37590/able.v42.art56.

11. J. J. Mulvihill& W. G. Wayne, *The Gregor Mendel Bicentennial Tribute—Enduring Mementos of the Founder of Genetics,***JAMA,**330(4), 2023, 297-298. Available online: https://doi.org/10.1001/jama.2023.9766.

12. Y. K. Türel, & O. Dokumaci, *Use of Media and Technology, Academic Procrastination, and Academic Achievement in Adolescence,***Participatory Educational Research**, 9(2), 2022, 481–97. Available online: https://doi.org/10.17275/per.22.50.9.2.

13. C. Vlădescu, *The Relationship between Mastery Learning Models and Academic Achievement in Mathematics,* **International Electronic Journal of Mathematics Education**, 18(4), 2023, em0751. Available online: https://doi.org/10.29333/iejme/13705.

14. Z. Yue, *A Study on Academic Optimism on the Academic Achievement of Secondary Education School in China*, **Journal of Digitainability, Realism & Mastery (DREAM)**, 1(5), 2022, 1–10. Available online: https://doi.org/10.56982/dream.v1i05.45.

15. D. W. Putwain, W. Peter & P. Reinhard, *Achievement Emotions and Academic Achievement: Reciprocal Relations and the Moderating Influence of Academic Buoyancy*, **Journal of Educational Psychology**, 114(1), 2022, 108–126. Available online: https://doi.org/10.1037/edu0000637.

16. T. Tikhomirova, M. Artem& M. Sergey, *Predicting Academic Achievement with Cognitive Abilities: Cross-Sectional Study across School Education,***Behavioral Sciences,** 10(10), 2020, 158. Available online: https://doi.org/10.3390/bs10100158.

17. T. M. Ibitoye, *Project-Based Learning and Self-Regulatory Strategies as Determinants of Secondary School Students' Achievement, Attitude and Practical Skills in Biology Concepts in Ibadan, Nigeria,* 2021, 1 – 196.

18. O. P. Adelana, M. A. Ayanwale& I. T. Sanusi, *Exploring Pre-Service BiologyTeachers' Intention to Teach Genetics using an AI Intelligent Tutoring - Based System*,**Cogent Education**, 11(1), 2024, 1 – 25. Available online: https://doi.org/10.1080/2331186X.2024.2310976

19. J. Giota, & B. Daniel, *Adolescent Academic, Social and Future Achievement Goal Orientations: Implications for Achievement by Gender and Parental Education,***Scandinavian Journal of Educational Research**, 65(5), 2020, 831–850. Available online: https://doi.org/10.1080/00313831.2020.1755360.

20. C. Hauspie, S. Stijn, D. Nicolas, F. Lot, S. Arnaud & D. Wouter, *Interactions of Gender with Predictors of Academic Achievement,* **Contemporary Educational Psychology**, 74, 2023, 102-186. Available online: https://doi.org/10.1016/j.cedpsych.2023.102186.

21. B. W. Julie, S. Jones & R. Thornton, *Boys Lagging behind: Unpacking Gender Differences in Academic Achievement across East Africa,***International Journal of**

Educational Development, 83, 2021, 102382. Available online: https://doi.org/10.1016/j.ijedudev.2021.102382.

22. V. G. Lalap Jr**.,** *Students' Academic Achievement and their Perception on the Use of Google Applications in Social Studies,* **EPRA International Journal of Research and Development (IJRD),** 6(7), 2021, 564 – 571. Available online: https://doi.org/10.36713/epra2016

23. A. Osuafor& G. P. Chinasa, *Effect of Flipped Classroom Instruction via Google Classroom on Secondary School Students' Academic Achievement Chemistry in Onitsha Education Zone,***UNIJERPS Unizik Journal of Educational Research and Policy Studies**, 15(3), 2023, 86 – 95. Available online: http://sjifactor.com/passport.php?id=21363

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Chapter Two

Literature Review

This chapter reviewed the relevant literature for the study. It was arranged under the subsequent subsections:

Conceptual Review

2.1.1 Academic Achievement

2.1.1 Academic achievement is the degree of mastery or skill that students achieve in academic disciplines, as shown by their results on tests, evaluations, and other learning markers[1]. It includes the acquisition of information, abilities, competences, and comprehension in one or more academic subjects. Educators, researchers, and policy makers can better understand students' learning outcomes and develop methods to promote and enhance Academic achievement in a variety of educational situations by taking into account dimensions of academic achievement. Student skill and comprehension in particular academic topics or content areas are referred to as content mastery. In a certain discipline or domain, it entails developing a thorough understanding of fundamental concepts, principles, abilities, and information[2].

Content mastery entails a thorough comprehension of the subject topic and extends beyond cursory familiarity. Instead of just memorizing facts or procedures, students show mastery when they are able to define, explain, and apply concepts in a variety of circumstances. Understanding the underlying ideas and concepts of a subject is necessary for content mastery. It entails establishing links between concepts within the subject area, recognizing patterns, and understanding the relationships between various concepts. The capacity to use information and abilities to solve issues, assess circumstances, and reach well-informed conclusions is a sign of content mastery. In addition to being able to solve hard issues on their own, students are also capable of applying their knowledge to new contexts and situations[3].Mastering the subject topic entails developing a profound and sophisticated comprehension of it. To properly analyze and assess material, students delve into the intricacies of the subject

matter, investigate complex subjects, and use higher-order reasoning and critical thinking. The development of certain abilities and capabilities pertinent to the subject matter is a component of content mastery. Depending on the content area, these could include abilities like scientific investigation, literary analysis, historical interpretation, mathematical reasoning, artistic expression, and technological expertise. Content mastery is generally assessed using a variety of ways, including tests, quizzes, projects, presentations, performances, portfolios, and displays of learning. These examinations examine students' abilities to apply their knowledge, solve problems, and exhibit mastery in the content area. Continuous learning, practice, and improvement are necessary for content mastery, which is a lifelong process. Over time, students attain higher degrees of mastery by continuously refining their skills, building upon their existing knowledge, and deepening their understanding[4].

Fostering content mastery requires establishing a supportive learning environment. This entails delivering stimulating and demanding educational opportunities, adapting the curriculum to the requirements of the students, creating inquiry- and exploration-focused learning environments, and offering constructive criticism and encouragement for development. By emphasizing content mastery, teachers can enable their students to get a thorough comprehension of academic subjects, foster critical thinking abilities, and develop into lifelong learners who are prepared to thrive in a world that is constantly changing[3, 4].

In the framework of Academic achievement, skill development refers to the development, application, and acquisition of cognitive and metacognitive abilities that are necessary for effective learning and problem-solving. The development of

cognitive skills allows students to process information, analyze issues, and come up with solutions. This is known as skills development. Among these abilities are: the capacity to assess data, reach well-reasoned conclusions, and approach problems methodically; the ability to recognize obstacles, formulates plans of action, and successfully carries out solutions; The capacity to evaluate data logically, reaches conclusions, and support claims with supporting data; the capacity to deconstruct difficult ideas or issues into digestible parts for examination; the ability to come up with creative concepts, methods, or answers for new or difficult issues[5].

Enhancing meta cognitive abilities is another aspect of skill development since it helps students keep focus on, control, and assess their own learning. These competencies consist of: recognizing and comprehending one's own methods of learning, as well as their advantages and disadvantages; the capacity for goal-setting, efficient time management, and motivational retention during educational activities; the ability to set priorities, plan, and arrange work in order to effectively accomplish learning objectives; the process of analyzing one's own learning experiences, recognizing obstacles and triumphs, and modifying communication tactics as necessary[3,6].Communication skills are included in skills development because they are essential for effectively presenting information, interacting with others, and expressing ideas. Among these abilities are: the capacity to express concepts in spoken language with assurance and clarity;the ability to communicate concepts, claims, and conclusions in a logical and well-organized manner through written prose; the ability to actively listen, understands, and reacts to others' verbal communication;

the ability to engage an audience, communicates information, and delivers presentations in an effective manner[3, 5, 6].

The ability to use technology for learning, research, communication, and productivity is a necessary talent in the digital age. These abilities include: the ability to efficiently obtain, assess, and apply information through the use of digital technologies and resources; the capacity to assess information sources critically, discern reliable sources from faulty ones, and combine data from many sources; the ability to use technology to improve effectiveness and involvement in projects, presentations, and learning activities[1,3].The process of developing skills entails cultivating cooperation and collaborative abilities, which are critical for success in both academic and professional contexts. Among these abilities are: the capacity to recognize, evaluate, and resolve complicated issues while cooperating well with others; the ability to collaborate and communicate with other team members in order to exchange ideas, assign tasks, and accomplish shared objectives; the capacity to establish rapport, settle disputes, and foster a positive team environment through positive interactions with others. Teachers can enable students to become active, engaged learners with the cognitive, metacognitive, communication, technical, and interpersonal skills required for academic success and lifetime learning by emphasizing skill development[6].

When discussing academic achievement, performance outcomes relate to the observable outcomes or measures of students' learning and competency in one or more subject areas. Students' academic achievement, development, and mastery of learning objectives are quantified by these outcomes. Grades are one of the most

widely utilized performance outcomes in evaluating students' academic success. They serve as a reflection of how well students performed on projects, tests, assignments, and other learning activities throughout a given time frame. The grading system or educational institution may use numerical scores, letter grades (such as A, B, or C), or other methods to determine grades. In academic evaluation, test scores are another commonly utilized performance result. They gauge how well students perform on standardized tests, evaluations, or exams intended to gauge their comprehension, aptitude, and mastery of certain subject matter. Test results are frequently utilized for comparisons because they offer a consistent indicator of students' intellectual ability[7].

Standardized assessments are examinations that are given to students on a regional, national, or worldwide scale with the aim of gauging their Academic achievement and comparing it to that of children in other schools, districts, or nations. Examples include state-mandated examinations that are in line with curricular standards and standardized achievement tests (like the WAEC, NECO and NABTEB). Periodically conducted during the academic year, benchmark evaluations track students' development and progress in respect to predetermined benchmarks or learning objectives. They give educators useful information on the strengths, shortcomings, and opportunities for growth of their students, enabling them to pinpoint those who might benefit from extra assistance or enrichment[6, 7].Formative assessments are continuous, non-formal evaluations that track students' learning progress in real-time and offer prompt feedback to influence instruction. They consist of exercises that assist student learning and inform instructional decision-making, such as exit tickets, quizzes, classroom debates, and observations. Summative tests

are given to students at the conclusion of a unit, course, or academic year in order to assess their overall Academic achievement and learning outcomes. They frequently consist of extensive tests, final assignments, portfolios, or culminating performances that assess students' understanding of course material and establish their course credit or final grade[7].

Academic scholarships, honor rolls, and rewards for academic excellence are examples of performance outcomes that recognize students for their exceptional academic achievements. They encourage students to pursue greatness and recognize their accomplishments in the classroom. Success in fulfilling academic requirements and being prepared to move on to the next phase of one's education are demonstrated by graduation rates and advancement to the subsequent grade level or educational milestone. They represent the completion of academic requirements and the preparedness of students for further study or employment. Education professionals, decision-makers, and other interested parties can evaluate students' academic progress, pinpoint areas in need of development, and endorse programmes and interventions that advance academic excellence and success for all students by concentrating on performance outputs[7,8].

The different cognitive, affective, and behavioral actions students partake in to gather, process, and integrate new information and abilities are referred to as learning processes. These procedures, which include a variety of learning-facilitating activities and tactics, are essential to the academic achievement of students. Learning processes entail the exposure to educational materials, resources, and experiences in order to acquire new knowledge, facts, concepts, and abilities. Reading textbooks, attending

lectures, viewing instructional films, and taking part in practical exercises are few of the examples of this. Information is encoded and stored in memory for subsequent use and retrieval as part of learning processes. By actively processing and arranging data into meaningful patterns, schemas, or mental representations, students participate in encoding. They then keep this knowledge for later use in either long-term or short-term memory[9].

When necessary, retrieving and recalling previously learned material from memory is a part of the learning process. Students' access stored knowledge and apply it to new activities or situations by using a variety of retrieval processes, including retrieval cues, recognition, and recall. The comprehension and understanding of knowledge, concepts, and ideas offered in instructional materials are all part of the learning process. In order to understand the material, develop connections between new and existing knowledge, and derive meaning from text or multimedia sources, students actively read, listen, and watch. Application and transfer of information and abilities to novel situations, issues, or tasks are all included in the learning processes. Students use the knowledge they have gained to solve issues, reach conclusions, finish tasks, and deal with difficulties they may encounter in the real world. Additionally, they spread knowledge among many domains or topic areas[10].

Practice and repetition are key components of learning processes as they help to solidify knowledge and promote conceptual and skill fluency. In order to master material, create automaticity, and gradually consolidate learning, students participate in purposeful practice, rehearsal, and review. Metacognition and reflection are two

aspects of learning processes that entail analyzing methods for improvement, tracking advancement, and reflecting on one's own learning process. Students evaluate their learning experiences, pinpoint their advantages and disadvantages, make objectives, and modify their approach to learning as necessary. Receiving performance feedback and utilizing it to modify and enhance learning objectives are key components of learning processes. To improve comprehension and mastery, students ask for and integrate feedback from teachers, peers, and self-assessment tools into their work[9, 10, 11].

Collaborative learning activities include problem solving, idea sharing, and group knowledge construction as part of the learning processes. Peer contact, communication skills, and cooperative problem-solving abilities are all enhanced by collaborative learning. Self-control and motivation are key components of learning processes because they help students define objectives, prioritize tasks, maintain focus and engagement, and persevere in the face of difficulties. Through the processes of goal-setting, self-reflection, and self-monitoring, students govern their own learning. Teachers may design curriculum that matches the different needs of their students, foster meaningful and long-lasting Academic achievement, and build effective learning environments by knowing and supporting these learning processes[6,10].

The term "socio-emotional development" describes the process of acquiring social and emotional knowledge, attitudes, and abilities that help people recognize and control their own emotions, build healthy connections with others, and successfully navigate social situations. Socio-emotional development is crucial for

influencing students' learning attitudes, their capacity to participate in the educational process, and their general well-being when it comes to academic success. Developing awareness and comprehension of one's own emotions, including differentiating them, figuring out what causes them, and comprehending how emotions affect attitudes, actions, and interpersonal interactions, are all parts of socio-emotional development.Socio-emotional development involves developing appropriate coping mechanisms for stress, frustration, and disappointment as well as the ability to control one's emotions in a variety of contexts[12].

The ability to sympathize with others, comprehends their viewpoints, and demonstrates compassion and concern for their feelings and well-being are all parts of socio-emotional development. This entails assessing other people's ideas and feelings during social encounters and acknowledging and reacting to their emotions. The process of developing social skills and competencies which are necessary for fostering healthy relationships and engaging in socially acceptable behavior is known as socio-emotional development. This covers abilities including cooperation, assertiveness, communication, active listening, and conflict resolution. Developing a positive self-concept and self-esteem is a component of socio-emotional development. This entails having a realistic and positive self-image, feeling confidence in one's skills, and acknowledging one's strengths and flaws[13].

In order to develop socio-emotionally, one must learn resilience the capacity to overcome obstacles, disappointments, and misfortune. Developing coping mechanisms, problem-solving techniques, and a spirit of hope and optimism in the face of adversity are all part of being resilient. Developing motivation and goal-

setting abilities, such as establishing reasonable objectives, remaining dedicated to attaining them, and persevering in the face of difficulties or failures, is a component of socio-emotional development. Developing social awareness entails recognizing and combating prejudices and stereotypes as well as comprehending social norms, cultural variations, and society expectations. These are all components of socio-emotional development[12,13].

Building a good rapport with family, friends, instructors, and other community members is a key component of socio-emotional development. Positive reinforcement, emotional support, and chances for social interaction and a sense of belonging are all provided by healthy partnerships[12]. In order to effectively handle conflicts and disagreements, people must learn to negotiate, compromise, and solve problems rather than using violence or avoidance. This is a key component of socio-emotional development. Teachers may establish a welcoming and inclusive learning environment that encourages academic engagement, social connectivity, and general well-being by supporting students' socio-emotional development. Socio-emotional abilities are linked to successful results in education, the workplace, and daily life and are crucial for academic achievement[13].

The different organizational structural and environmental forces that mold students' learning experiences and results are referred to as contextual factors in the context of academic accomplishment. These elements cover the school, classroom, home, community, and larger sociocultural context, among other elements of the learning environment. The general atmosphere, social environment, and culture of the school are referred to as the "school climate." Student academic engagement,

motivation, and well-being are enhanced by positive school climate elements like a sense of safety, belonging, and support[14]. A key factor in academic success is the caliber of instruction and teaching. In addition to differentiating instruction to accommodate the unique needs of their students, effective teachers also build positive relationships between themselves and their students in the classroom by creating engaging and supportive learning environments[15].

The planning, delivery, and arrangement of instructional materials and learning opportunities are all included in the curriculum design. Students have chances for mastery and application of knowledge and skills, as well as clear learning goals and relevant instruction, from a well-designed curriculum that is in line with standards and objectives. Teaching strategies, tactics, and methods that instructors employ to support learning in the classroom are referred to as instructional practices. Inquiry-based learning, customized education, active learning, cooperative learning, and the use of technology to engage students and encourage deeper learning are examples of effective instructional strategies[14, 15].

Academic attainment can be strongly impacted by the degree of support and involvement that families and caregivers. Students' motivation, attitudes towards learning, and academic success are influenced by supportive home environments, positive family-school connections, and parental involvement in education. Students' social and intellectual development is influenced by the relationships and interactions among their peers in the school setting. While negative peer impacts can erode students' academic motivation and achievement, positive peer interactions offer chances for collaboration, social support, and academic engagement[11].Students'

academic success may be impacted by the facilities, resources, and learning opportunities that are available in the community and at school. Sufficient resources, including labs, libraries, technology, textbooks, and extracurricular activities, facilitate students' learning and improve their educational experiences. One important contextual aspect that affects academic achievement is socioeconomic status (SES). The Academic achievement of students from lower socioeconomic origins may be negatively impacted by the obstacles they confront in getting access to opportunities, resources, and support networks[11,16].

Student experiences and academic results are influenced by the diversity of cultures and languages present in the school population. Equity and academic success for all students, regardless of background, are promoted by culturally sensitive teaching methods, inclusive curricular materials, and language development support. Local, state, and federal educational policies, standards, and accountability frameworks can impact students' learning experiences and results while also influencing educational practices and goals. Higher academic attainment is a result of policies that enable equitable access to high-quality instruction, learning accountability, and equal resources. Educators, legislators, and other stakeholders can provide inclusive, supportive learning environments that support academic success for all kids, regardless of background or circumstance, by being aware of and responding to these contextual elements. A comprehensive approach to education reform and development is crucial since contextual factors have a complicated and linked impact on students' academic achievement[11, 17].

In the context of academic achievement, long-term outcomes are the enduring impacts and results of students' educational experiences on their future chances, trajectories, and life outcomes. These results go beyond simple academic achievement to include more comprehensive measures of social, career, and personal accomplishment. The degree of education attained by an individual, such as high school graduation, enrollment in postsecondary education, completion of vocational training, acquisition of higher education degrees (such as associate's, bachelor's, master's, or doctorate degrees), and certification in specialized fields, are examples of long-term outcomes. A person's ability to grow in the workforce and obtain employment prospects is influenced by their academic attainment. Increased employment opportunities, job stability, earning potential, and access to better-paying and more rewarding career choices are all correlated with higher educational attainment levels[12, 15, 16].

The earning potential and economic mobility of an individual are correlated with their academic achievement. Higher education makes people more capable of landing better jobs and advancing in their careers, which in turn leads to higher wages, more financial stability, and more prospects for upward social mobility. Academic success affects how people's physical and mental health turns out. Greater life expectancy, less chronic disease rates, and enhanced general well-being are all linked to higher levels of education and better health outcomes. People who have received an education are also better equipped to make judgments regarding their lifestyle and health[11, 13].

Academic achievement encourages civic engagement and involvement in local and national politics. Higher educated people are more likely to engage in civic duties including voting, volunteering, community service, and social cause advocacy, which makes them more knowledgeable and involved citizens. Accomplishment in school helps people create networks and social capital that give them access to opportunities, resources, and support systems. By introducing people to a variety of social networks, mentors, and role models, as well as by building connections with peers, coworkers, and community members, education promotes social mobility[2, 12].

Academic achievement gives people life skills that are necessary for overcoming obstacles and adjusting to changes in life. These abilities include critical thinking, problem-solving, communication, and adaptation. Additionally, resilience is fostered by education, which aids people in overcoming hardships, disappointments, and unforeseen life occurrences. Academic achievement allows people to follow their passions, interests, and objectives, which enhance their sense of personal fulfillment and happiness. Education boosts people's sense of fulfillment and purpose in life by offering chances for self-expression, creativity, personal growth, and lifetime learning[2, 11].

Academic achievement affects not just the person but also their families and subsequent generations. Better results for students, such as enhanced academic achievement, greater educational attainment, and more socioeconomic prospects, are linked to higher levels of parental education. Academic success encourages intercultural competency, empathy, and a respect for diversity, all of which contribute to the development of global citizenship and cultural understanding. People who have

received an education are better able to interact with global concerns, comprehend diverse viewpoints, and make a positive impact on a more inclusive and interconnected society. Educators, legislators, and other stakeholders can better understand the long-term effects of academic success on people's lives and society at large by taking these long-term outcomes into account. They can then seek to develop educational opportunities and systems that support successful learning outcomes for all students[9, 10].

2.1.2 Gender

The status of being male or female in respect to the roles that are seen suitable for men and women in society and culture is known as gender. The term "gender identity" describes a person's firmly held belief about their own gender, which may or may not match the sex they were given at birth. Gender identity is not the same as biological sex; it's a range of identities that goes beyond the binary classifications of male and female. Others identify as non-binary, despite the fact that many people identify as either male or female. Non-binary people can identify as a gender that is wholly distinct from male and female, as a blend of genders, or as neither exclusively male nor exclusively female. While gender people identify as the same sex as they were assigned at birth, transgender people identify as someone whose gender does not match their assigned sex. A person undergoing transitioning may need to take social, medical, or legal actions to match their gender identification and gender expression[18].

Gender identity is flexible and subject to change. Before settling on a gender identity or expression that seems true to them, some people may experiment with a

variety of them. Gender exploration is an individual journey that can entail self-exploration, challenging social conventions, and looking for outside support. Other facets of identity, such as race, ethnicity, culture, sexual orientation, disability, and socioeconomic status, interact with gender identity. People's perception of their gender identity and their ability to negotiate social interactions, institutions, and oppressive systems are shaped by their intersectional experiences[17, 18].

Gender expression, or how people show their gender to the outside world through their attire, haircuts, mannerisms, and other behaviors, is closely linked to but separate from gender identity. Gender expression is highly without collaborative and may or may not correspond with one's gender identification. Different nations and jurisdictions have different laws recognizing gender identification. Laws and regulations in certain nations, such as those prohibiting discrimination, recognizing gender identity on official papers, and granting access to healthcare that is gender affirming, safeguard the rights of transgender and non-binary people[19].

Advocate groups, organizations, and supportive communities are essential in promoting the rights and welfare of non-binary and transgender people. These organizations empower people and advance inclusivity and acceptance by offering resources, instruction, advocacy, and community support. People who identify as transgender or non-binary may experience prejudice, stigma, and marginalization because of their gender identification. This can take many different forms, including as assault, harassment, discrimination at work, unequal access to healthcare, and obstacles to receiving care that is gender affirming[16, 19].

Greater awareness, acceptance, and comprehension of various gender identities are facilitated by increased visibility and depiction of transgender and non-binary people in literature, the media, and public discourse. In order to dispel prejudices, foster empathy, and validate the experiences of people of different gender identities, representation is important. Affirming people's dignity, autonomy, and sense of self requires respecting their self-identified gender identity and using their preferred name and pronouns. Fostering a sense of belonging and well-being for all depends on establishing inclusive and affirming environments that celebrate variety and show respect for all gender identities. It is crucial to comprehend and honor various gender identities in order to build welcoming and encouraging societies where everyone may flourish and live true to themselves. Societies may strive for greater equality and justice for all by supporting transgender and non-binary people through activism, affirmation, and acceptance[18, 19].

Social conventions and stereotypes known as gender roles and expectations dictate particular behaviors, roles, and characteristics based on an individual's perceived or ascribed gender. Different cultural, historical, and social contexts will have different roles and expectations, which can have an impact on an individual's behavior, opportunities, and relationships, among other areas of their life. Based on assumed biological differences, traditional gender norms frequently dictate different responsibilities and behaviors for men and women. Expectations about jobs, family roles, housework, emotional expression, and social interactions are a few examples of these norms. Gender roles generally involve expectations about what it means to be a man or a woman, as well as expectations about how people should act, dress, and

show themselves. While feminine traits are linked to domesticity, empathy, nurturing, and sensitivity, masculine traits are linked to strength, assertiveness, independence, and leadership[19, 20].

The division of labor within families and communities is frequently influenced by gender norms, which dictate that men and women should handle separate jobs and duties. Gender differences in workload, time allocation, and economic possibilities can be attributed to several factors such as caring, domestic tasks, financial provision, and decision-making responsibilities. Social expectations shape preferences, goals, and possibilities in various fields of study and occupations, and gender roles can impact people's educational and career choices. Preconceived notions about what kinds of jobs are suitable for each gender can deter people from choosing unconventional career paths and help to maintain gender inequality in some industries[20].

Expectations for parenting and providing care, as well as roles and obligations within families, are influenced by gender roles. The idea that fathers are the primary breadwinners and mothers are the primary caregivers may be reinforced by traditional gender norms, which may have an impact on family dynamics, childcare arrangements, and parental participation. Gender roles have an effect on how people express their emotions since social norms determine which feelings are permissible or acceptable for a given gender. Women may be taught to show nurturing and empathy, whereas men may be socialized to repress vulnerability and exhibit stoicism[20, 21].

Gender roles influence interpersonal dynamics, social behaviors, communication styles, and other aspects of social interactions and relationships.

These norms may affect how people relate to authority figures, romantic partners, coworkers, and peers. They may also affect how power and influence are distributed throughout social groups. Popular culture, advertising, entertainment, and media portrayals all frequently reinforce and maintain gender norms and expectations. Harmful stereotypes can be reinforced and society perceptions, attitudes, and ideas regarding gender roles can be shaped by the stereotypical representations of men and women in the media[19, 22].

Gender variety, fluidity, and equality are now more widely acknowledged as a result of challenges to established gender roles and expectations posed by advocacy campaigns, cultural changes, and changing societal norms. There is an increase in tolerance and acceptance of various gender identities and expressions as a result of initiatives to advance gender parity, demolish stereotypes, and question inflexible gender standards. Gender roles shape people's perceptions of gender and affect their access to opportunities, resources, and social privileges. They also overlap with other aspects of identity, such as race, ethnicity, class, sexual orientation, and disability. Understanding gender roles from intersectional perspectives emphasizes the complexity of identity and the need to confront various forms of inequality and discrimination. Societies should endeavor to create more inclusive, egalitarian, and supportive environments where people are free to express themselves honestly and achieve their goals without constraints based on gender by recognizing and opposing restrictive gender norms and expectations. Everyone gains when gender equality is promoted because it encourages diversity, creativity, and social justice[19, 21].

Gender stereotypes are simplistic, frequently inflexible ideas or presumptions about the qualities, attributes, roles, and actions that are considered normal or suitable for people according to their perceived or given gender. These prejudices have the power to shape people's views about men, women, and people of different gender identities as well as their expectations and behaviors. Men and boys are usually portrayed in masculine stereotypes as being independent, competitive, rational, strong, and emotionally stoic. Characteristics linked to masculinity encompass physical prowess, self-reliance, risk-taking, and professional achievement; conversely, emotional susceptibility, empathy, and caring attributes may be marginalized or stigmatized. Stereotypes about femininity frequently portray women and girls as relationship and appearance-focused, passive, sensitive, sympathetic, and nurturing. Caring, domesticity, empathy, and physical attractiveness are traits that are often linked with femininity; assertiveness, ambition, and intellectual pursuits are traits that may not be seen as desirable or suitable[20, 22].

Perceptions of appropriate careers and vocations depending on gender might be influenced by gender stereotypes. Gender norms and expectations may be linked to particular professions, which can result in occupational segregation and unequal employment chances. For instance, STEM professions are frequently associated with men, but service and caring professions are associated with women. The expectations of stereotypical gender roles also apply to family caregiving and parenting roles. Men are expected to prioritize providing for their families financially and may be less active in childcare or household chores, whereas women are typically assumed to be the major caregivers, handling childcare, emotional support, and household chores[21].

Expectations regarding sexuality, romantic relationships, and gender roles in partnerships can be influenced by gender stereotypes. With men expected to begin relationships, pursue sexual conquests, and exert authority, and women supposed to be submissive, nurturing, and sexually modest, hetero-normative stereotypes have the potential to perpetuate traditional gender norms. Social standards of attractiveness, appearance, and body image are influenced by gender stereotypes and might vary depending on a person's gender. While women may be expected to adhere to standards of thinness, youthfulness, and physical attractiveness, men may feel pressure to conform to muscular and athletic ideals, which could lead to unhealthy behaviors and body dissatisfaction[22].

Gender stereotypes set expectations for emotional expression and vulnerability; women are supposed to be loving, sympathetic, and emotionally expressive, while men are urged to repress feelings like fear, sadness, and vulnerability in order to maintain a stoic façade. Popular culture, advertising, entertainment, and media depictions all frequently reinforce and propagate gender stereotypes. Stereotypical representations of men and women in the media have the power to affect people's self-concept and aspirations as well as social attitudes, views, and beliefs around gender roles[19].

Gender stereotypes can negatively impact a person's opportunities, mental health, well-being, and sense of self. Adhering to inflexible gender stereotypes may limit people's ability to be authentically themselves, follow their passions and objectives, and get equal rights and opportunities. In order to advance gender equity, diversity, and inclusion, gender stereotypes must be challenged and destroyed. To

challenge preconceptions and build more inclusive and equitable societies, it can be helpful to educate people about the negative consequences of stereotypes, to support positive representations of varied gender identities and expressions, and to develop critical thinking skills. Societies can foster settings where people of all genders are respected, valued, and enabled to realize their full potential by dispelling gender stereotypes and embracing a variety of gender identity and behavior expressions. Everyone gains when gender equity is promoted because it encourages diversity, creativity, and social justice[20].

Gender socialization refers to the process by which people pick up and assimilate social standards, expectations, beliefs, and behaviors that are connected to their given or perceived gender. It starts early and is facilitated by a variety of socialization factors, such as peers, family, schools, the media, and cultural organizations. Gender socialization affects people's attitudes, behaviors, and interactions throughout their lives by forming their conception of gender roles, identities, and relationships. One of the main settings for gender socialization is the family; via interactions with parents, siblings, and other family members, children are taught about gender norms, behaviors, and expectations. Gender stereotypes can be perpetuated by parents either intentionally or inadvertently by their language, the toys they offer, the jobs they assign, and the responsibilities they take on in the home. Peers are important in the process of gender socialization because they teach kids and teenagers about gender identities, norms, and relationships through their interactions with peers and classmates. Through peer pressure, social standards, and expectations

for adhering to gender norms within peer cultures, peer groups can perpetuate gender stereotypes[19, 20, 23].

Schools play a significant role in the gender socialization of children and adolescents by providing them with formal and informal signals on gender norms, expectations, and roles. Gender stereotypes may be reflected and reinforced by teachers, curriculum materials, textbooks, and school policies, which can have an impact on students' academic decisions, interactions, and behaviors. The mass media, which includes movies, TV shows, commercials, and internet content, has a significant impact on how people view gender and how gender stereotypes are reinforced. Media images of masculinity and femininity are frequently limited and idealized, which has an impact on people's attitudes towards others, goals, and self-concept[20].

Play activities and toys are crucial instruments for gender socialization because they teach kids about gender norms and expectations through the things they play with and do. By endorsing toys that are gender-specific and perpetuating traditional gender roles (e.g., trucks for boys, dolls for females), toy marketing frequently contributes to the perpetuation of gender stereotypes and limits children's freedom to explore and express themselves. People's knowledge of gender roles and identities is influenced by religion and cultural beliefs, which in turn create gender norms, values, and expectations. Religious doctrine, cultural conventions, rituals, and practices can either question or reinterpret gender norms in ways that support equality and inclusion, or they can perpetuate traditional gender roles and hierarchies[21,24].

Through encounters in the job, in schools, and in other social settings, gender socialization continues throughout adulthood. Individuals' career chances, aspirations for leadership, and professional experiences may be impacted by organizational cultures, policies, and practices that reflect and maintain gender prejudices, discrimination, and injustices. Gender socialization is greatly influenced by language, since people pick up gendered vocabulary, idioms, and social mores at an early age. By upholding gendered norms for conduct, appearance, and roles, gendered language contributes to the perpetuation of stereotypes and inequities[24].

Individuals and communities may oppose and fight these conventions, fostering alternative ideas of gender equality, diversity, and inclusion, even if gender socialization frequently perpetuates old gender norms and stereotypes. Social movements, lobbying initiatives, and cultural transformations play a pivotal role in contesting gender stereotypes and fostering more just and comprehensive communities. Gender experiences and access to opportunities, resources, and social privileges are shaped by the intersections of gender socialization with other dimensions of identity, including race, ethnicity, class, sexual orientation, and disability. Gender socialization is better understood through intersectional perspectives, which emphasize the complexity of identity and the need to address various forms of inequality and discrimination. Stakeholders can work to promote more equitable, inclusive, and empowering environments where all people are free to express themselves authentically, challenge stereotypes, and pursue their aspirations without limitations based on gender by understanding the process of gender

socialization and its impact on individuals and society. Diversity, innovation, and social justice are all enhanced by the advancement of gender equality[25, 26, 27].

The term "intersectionality," developed by legal scholar Kimberlé Crenshaw, emphasizes how social identities, oppressive structures, and experiences of privilege and discrimination are all intertwined. It acknowledges that a person's experiences and possibilities in society are shaped by the intersections and interactions of their numerous social identities, including those related to race, gender, class, sexual orientation, disability, and nationality. In contrast to being defined by a single identity, intersectionality highlights that people are characterized by the intersections of numerous identities, which can cross in intricate ways to influence how people experience privilege and oppression. For instance, a black woman may encounter marginalization that is different from that of black men or white women due to prejudice based on both race and gender. The concept of intersectionality acknowledges the connections and mutual reinforcement between oppressive systems such as ableism, homophobia, trans-phobia, sexism, racism, and classism. These interlocking oppressive structures intensify inequality and hurdles to equality by producing particular kinds of prejudice and disadvantage for people with marginalized identities[28].

Persons of color, immigrants, members of religious minorities, and people with disabilities are just a few examples of the groups whose experiences are illuminated by intersectionality. It can be difficult to meet these people's needs and experiences using one-dimensional methods because of the intersecting forms of violence, exclusion, and discrimination they may encounter. This is because their

identities are not monolithic. Intersectionality also recognizes that people's social identities such as being white, male, cisgender, wealthy, educated, or national account for intersecting types of privilege and power that they possess. Resources, opportunities, and social mobility are shaped by the intersections of these privileges, which bestow advantages and opportunities on members of society[29].

Intersectionality recognizes that people's experiences are molded by a variety of intersecting aspects and influenced by historical, cultural, and structural contexts. It also stresses the complexity and context-dependent nature of identity and oppression. It promotes holistic, complex methods of comprehending and resolving inequality that take into consideration the ways in which privilege and power interact[29]. In feminist theory and action, intersectionality has had a particularly significant impact, pushing mainstream feminism to be more inclusive and intersectional in its campaigning and analysis. In order to address the intersecting forms of oppression that marginalized women such as women of color, handicapped women, and women from a variety of socioeconomic backgrounds face, intersectional feminism aims to center their experiences[28].

By supporting laws, plans of action, and other measures that tackle the intertwined needs and experiences of disadvantaged people and communities, intersectionality contributes to the advancement of social justice and equity. It demands methods that give voice and importance to the experiences of those most impacted by systemic injustice while acknowledging and addressing the complexity of identity and oppression. In addition to encouraging people to consider their own social identities, privileges, and biases, intersectionality also promotes critical

consciousness and reflexivity by pointing out the ways in which intersecting systems of oppression function in society. In order to combat inequality and build more inclusive and equitable communities, it calls on people to take up solidarity and group action. Promoting intersectional approaches to advocacy, policymaking, and social change can help address systemic inequalities and build more resilient and inclusive communities for all. By embracing intersectionality as a framework for understanding identity and oppression, individuals, organizations, and societies can work towards more inclusive, equitable, and just social systems that honor the diversity and complexity of human experiences[28, 29].

Gender inequality is the term used to describe differences and discrimination between people based on their gender, which results in unequal opportunities, outcomes, and treatment in a variety of life domains. It impacts persons of all genders and has social, economic, political, and cultural components, albeit it mostly harms women and non-binary people. Inequality in access to resources, financial security, and economic opportunities due to one's gender is a sign of gender inequality. Compared to men, women frequently experience lower pay, occupational segregation, fewer prospects for career growth, and greater rates of poverty. Throughout the world, there is still a gender pay gap, meaning that women are paid less for doing similar work than men, which adds to lifetime economic inequality. The term "gender inequality in education" describes differences in academic achievement, enrollment, retention, and quality of education based on a person's gender. While progress has been made in increasing girls' access to education worldwide, disparities persist, particularly in regions with entrenched gender norms and cultural barriers. Girls may

face obstacles such as early marriage, gender-based violence, and lack of access to educational resources, limiting their educational attainment and opportunities[18, 30].

Women and non-binary people are disproportionately underrepresented in political leadership positions, governmental organizations, and decision-making bodies, demonstrating gender imbalance in political representation and decision-making processes. Women's participation in politics and governance is hampered by structural impediments, discrimination, and gender stereotypes, which limits their voice and influence in shaping laws and policies that impact their daily lives. Gender inequality has an impact on reproductive rights, health outcomes based on gender, and access to healthcare services. Access to maternal healthcare, contraception, reproductive healthcare, and treatment for gender-specific health conditions may be impeded for women and non-binary people. Discrimination and gender norms can also have an effect on mental health outcomes, with women and non-binary people experiencing higher rates of trauma, anxiety, and depression[30, 31].

Violence, discrimination, and gender-based violence such as violence against intimate partners, sexual harassment, human trafficking, and destructive customs like child marriage and female genital mutilation are all exacerbated by gender inequality. Gender-based violence is mostly directed towards women and non-binary people. It stems from power imbalances, patriarchal standards, and systemic injustices. Social conventions, preconceptions, and expectations that specify acceptable roles, behaviors, and characteristics based on gender all contribute to gender disparity. Gender stereotypes restrict people's freedom, opportunities, and choices, which feeds into the cycle of discrimination and injustice. The prejudice, stigma, and exclusion

that marginalized gender identities and expressions must deal with may also be a result of harmful preconceptions[25, 32].

People's experiences of privilege and oppression are shaped by the intersections between gender inequality and other forms of inequality, including those based on race, ethnicity, class, sexual orientation, disability, and country. The complexity of identity and the intersecting dynamics of power and discrimination are acknowledged by intersectional approaches to gender inequality, underscoring the necessity of inclusive and intersectional solutions that address various types of inequality at once. Discriminatory laws, policies, and practices that restrict the opportunities and rights of women and non-binary people serve to reinforce and maintain gender inequality. In order to achieve gender equality, defend human rights, and address systematic discrimination and bias, efforts to address gender inequality must involve institutional changes, policy initiatives, and legislative reforms. Comprehensive and multifaceted strategies that address the underlying causes of inequality, question discriminatory norms and practices, and advance social justice and gender equality are needed to address gender inequality. Achieving sustainable development and equal rights for all genders requires empowering women and non-binary people, advocating for gender-responsive policies and programmes, and building inclusive and equitable societies[25, 31, 32].

The intersections between gender and education are multifaceted, impacting people's academic experiences, outcomes, and access to educational opportunities. People's access to education can be impacted by their gender, especially in areas where chances for particular genders are restricted due to socioeconomic or cultural

restrictions. Gender-based violence, lack of infrastructure, and enrollment restrictions has all historically prevented girls and women from obtaining education. The goal of initiatives to advance gender equity in education has been to remove these obstacles and provide greater access for all genders. There could be gender differences in participation and enrolment rates at various educational levels. Certain circumstances, such as early marriage, domestic duties, or cultural norms that prioritize males' education, may cause girls to enroll in school less frequently or drop out at higher rates than boys. In order to close these gaps, specific actions must be taken to advance gender-sensitive policies and programmes and assist girls' education[33].

Research indicates that gender can have an impact on academic accomplishment, with differences in performance observed across many topics and educational levels. Boys may score better in math and science, but girls may perform better in language arts and other disciplines. Numerous factors, including as socialization, instructor biases, learning settings, and educational resources, may have an impact on these inequalities. Gender has the power to influence people's educational paths and choices, including their choice of majors, desired careers, and post-secondary possibilities. Gender-segregated educational paths and job areas can result from stereotypes and cultural expectations about gender roles influencing people's perceptions of their skills and interests. Students' educational experiences and outcomes may be impacted by gender prejudices among teachers and in the classroom. Studies have indicated that educators could unintentionally contribute to the perpetuation of gender norms by, for example, favoring boys over girls in math and science classrooms or discouraging the latter from pursuing traditionally male-

dominated subjects. These impacts can be lessened by establishing gender-inclusive classrooms and raising awareness of biases[26, 33].

There are differences in gender representation and leadership roles in educational institutions, especially among teachers, administrators, and decision-makers. Despite making up a sizable fraction of the teaching workforce, women are frequently underrepresented in leadership positions, especially in higher education. In order to alleviate these discrepancies, initiatives to support inclusive leadership and gender diversity are crucial. The experiences and results of students' education might be adversely affected by gender-based abuse and harassment. In educational environments, girls and women may experience gender-based violence, such as sexual harassment, assault, and bullying. This can have a negative impact on attendance, academic achievement, and general well-being. Addressing these problems and advancing gender equity in education need the creation of secure and encouraging learning environments[25, 26, 33].

Adapting teaching strategies and curriculum materials to the unique learning requirements and experiences of students of all genders is known as gender-responsive pedagogy. This method aims to establish inclusive learning settings that support fairness and diversity while acknowledging the influence of gender on learning styles, interests, and identities. Policymakers, educators, and stakeholders can work towards promoting gender equity, building inclusive learning environments, and guaranteeing that every person has equal opportunity to realize their educational potential by acknowledging and addressing the intersections of gender and education[33]

2.1.3 Digital Learning Platforms

Digital learning platforms explain how technology may be used to improve learning. Its vast collection of tools, platforms, and resources may help students of all ages and backgrounds improve their academic achievement and personal growth. The methods, ideas, and approaches that teachers employ to support learning and encourage student participation, comprehension, and accomplishment are known as teaching strategies. As a result of technological improvement, teaching strategies now include digital tools and resources[34]. Blended learning is the integration of online learning resources and activities with traditional in-person training. Students that follow the flipped classroom approach participate in class activities, debates, and concept application during class time, while they also interact with educational information outside of the classroom (for example, by watching videos or reading books online). Multimedia presentations, interactive simulations, and learning management systems are just a few examples of the educational technology tools that can improve instruction. Technological integration in education involves the incorporation of digital tools, resources, and technologies to enhance teaching and learning experiences. Teachers may design dynamic, personalized, and engaging learning experiences that equip students for success in the digital age by carefully and purposefully incorporating technology into teaching and learning[35].

A vast range of technologies that assist teaching, learning, and educational administration are included in the category of digital tools and resources in education. Platforms known as Learning Management Systems (LMS) act as focal points for handling examinations, facilitating communication, arranging course materials, and

monitoring student progress[36]. Moodle, Canvas, Blackboard, and Google Classroom are a few popular LMS choices. With the help of interactive whiteboards, which blend classic whiteboard features with digital ones, educators can present multimedia materials, annotate lessons, include students in interactive activities, and work together in real time. Interactive whiteboard systems include SMART Board and Promethean ActiveBoard[37].

Many platforms (web, desktop, and mobile) offer a wide selection of educational software and apps for a range of subjects, grade levels and learning goals. These consist of instructional, productivity tools, games, simulations and apps for creating content. A multitude of educational resources, such as worksheets, lesson plans, interactive learning tools, articles, videos and eBooks, are available online. Resources that are freely available for use, sharing and adaptation for educational purposes without copyright limitations are online resources and open educational resources (OER). Digital resources including e-books, journals, research papers, multimedia, and archive records are collected and stored in digital libraries and repositories. JSTOR, PubMed Central, Project Gutenberg, and Google Books are a few examples. Project-based learning, synchronous and asynchronous communication, and cooperation between students and professors are made possible via collaboration technologies. These resources include cloud-based document sharing and editing tools (like Google Drive, Microsoft One Drive), chat apps (like Slack, Microsoft Teams), video conferencing platforms (like Zoom, Microsoft Teams), and virtual white boarding tools[35, 38].

Assessment and feedback tools make it easier to create, administer, grade, and provide feedback to students on assessments. These resources include peer review sites, plagiarism detection software, grading rubrics, and online assessments and quizzes. Students can produce and distribute multimedia-rich presentations, films, podcasts, animations, and digital stories by using multimedia tools and digital storytelling. Canva, iMovie, Audacity, and the Adobe Creative Cloud suite are a few examples. Platforms for coding and programming offer interactive settings for teaching computational thinking and computer programming; some examples are the programming courses offered by Khan Academy, Code.org, Tynker, and Scratch. Through the creation of virtual and augmented reality settings (VR and AR, respectively), and the overlaying of digital content onto the real world (AR), these technologies provide immersive and experiential learning opportunities. These tools can be used for interactive learning, simulations, and virtual field trips. Through the proper utilization of digital tools and resources, educators may improve student engagement, tailor learning experiences, encourage teamwork, and assist in the development of 21st-century skills[37, 39].

Blended learning combines traditional classroom instruction with elements of online learning, including digital resources, multimedia content, and interactive exercises. With this hybrid method, learning activities and resources can be accessed by students both in-person and virtually. This is usually accomplished through the use of learning management system (LMS) or other online platform. Students can access materials outside of the classroom and learn at their own pace with blended learning, which allows flexibility in the delivery of instruction and content. Because of this

versatility, learning experiences may be customized to meet the requirements, interests, and learning preferences of each individual learner. Multimedia presentations, online tutorials, interactive exercises, group projects, lectures, conversations, and simulations are all included in blended learning. Blended learning accommodates a range of learning styles and fosters comprehension and engagement by integrating several teaching methods[40].

The flipped classroom model is a popular blended learning strategy in which students participate in class activities, discussions, and concept application during class time, while also interacting with instructional information outside of class (e.g., through readings, recorded lectures, or online modules). More interactive and collaborative learning opportunities in the classroom that emphasize problem-solving, critical thinking and knowledge application are made possible by this inverted teaching style. Individualized practice, support, and feedback for students are made possible through blended learning, which makes differentiated instruction easier to implement. Instructors can monitor student progress, spot learning gaps, and modify lessons by using data analytics, adaptive learning platforms, and online examinations. Through collaborative document editing tools, online discussion forums, group projects, and virtual office hours, blended learning encourages communication and collaboration between students and teachers. Digital communication channels enable cooperative problem-solving, knowledge sharing, and peer involvement[41].

For blended learning to be implemented successfully, educators must receive continuous professional development and assistance. Teachers can gain the knowledge, abilities, and confidence to successfully create and implement blended

learning experiences by participating in training programmes, seminars, mentoring, and peer collaboration opportunities. Numerous advantages come with blended learning, such as greater flexibility, individualized instruction, improved engagement, easier access to materials, and chances for communication and teamwork. Blended learning has the potential to establish dynamic and productive learning environments that equip students for success in the digital age by utilizing the advantages of both traditional and online learning modalities[42].

The flipped classroom is an instructional strategy that flips the conventional teaching model by having students carrying out assignments outside of class and using class time for discussions, active learning, and idea application. Pre-class learning materials are given to the students to review on their own time after class. These resources may consist of readings, interactive modules that present new ideas and information, pre-recorded video lectures, and online tutorials. During class, the topics taught in the pre-class training are reinforced and applied through discussions, cooperative activities, and active learning. As facilitators, teachers lead groups of students through talks, problem-solving exercises, and group activities[41, 43].

In order to support student-centered learning, the flipped classroom paradigm moves the emphasis from teacher-led instruction to student-centered activities and interactions. Inquiring, collaborating, and exploring ideas are some of the more active ways that students engage in their education. In order to accommodate students' varied learning requirements and preferences, individualized instruction is made possible via the flipped classroom. Students can participate in activities in class that

are tailored to their unique learning styles and skills, review pre-class materials at their own pace, and pause, rewind, and revisit subject as necessary[44,45].

The flipped classroom concept can boost student enthusiasm, engagement, and involvement by offering chances for interactive learning and engagement throughout class time. When students have been exposed to the material previously, they are more likely to participate actively in discussions, problem-solving exercises, and peer interactions. During class activities, students collaborate to solve issues, exchange ideas, and share thoughts, which are fostered by the flipped classroom model. Collaborative problem solving, information sharing, and peer engagement are all facilitated by collaborative learning experiences. Class time in the flipped classroom is focused on applying and reinforcing the concepts taught during pre-class instruction. In order to enhance their knowledge and abilities, students can participate in practical exercises, case studies, simulations, and other application exercises. Overall, the flipped classroom model offers a student-centered, active learning strategy that employs technology to optimize instructional delivery, boost engagement, and enhance learning outcomes. Teachers may build dynamic and engaging learning environments that enable students to take charge of their education and achieve academic success by flipping the standard teaching model[41, 46, 47].

Distance learning and online education relate to instructional methods and educational programs given remotely, generally using digital technology and the internet. Distance learning and online education give flexibility in terms of time, place, and speed of study. Students can access course materials, lectures, and assignments from anywhere with an internet connection, allowing them to learn at

their own pace and fit their studies around other responsibilities. Digital platforms and tools are essential to the delivery of educational information, communication, and activity management in online learning. Learning Management Systems (LMS), video conferencing software, discussion forums, and multimedia materials are routinely utilized to provide dynamic and engaging learning experiences[48].Access to a vast array of courses and programmes covering several subjects and disciplines is made possible by online education. Online learning platforms, businesses, and educational institutions provide students with a wide range of professional development possibilities, degree programmes, and online courses. Online education offers for customizable learning experiences geared to individual student needs, interests, and learning styles. Adaptive learning technology, individualized learning paths, and self-paced courses enable students to receive tailored instruction and support depending on their learning goals and skills[49].

Online education encourages interactive instruction and engagement through a variety of communication methods and interactive features, despite the physical distance between students and teachers. Virtual classrooms, live webinars, discussion boards, and multimedia presentations offer real-time contact, cooperation, and feedback between students and teachers. By eliminating geographic boundaries and offering chances to students who might find it difficult to attend traditional educational settings, online education fosters inclusivity and accessibility. The flexibility and accessibility of online learning can be advantageous for persons with hectic schedules, working professionals, careers, and students with impairments. A variety of assessment techniques and resources are used in online education to

appraise student progress and offer comments. Instructors can evaluate students' progress and comprehension through online tests, assignments, quizzes, and peer assessments. They can also provide timely feedback to support learning objectives. Micro-credentials, online courses, and continuing education programmes are some of the ways that online education promotes lifetime learning and professional development. Online learning tools help professionals stay up to date in their industries, improve their abilities, and stay knowledgeable[50].

Both individuals and educational institutions may find online learning to be a financially advantageous option. Institutions can lower overhead costs connected to physical facilities and resources, while students can save on costs related to accommodation, transportation, and textbooks. Online learning has numerous advantages, but it also has drawbacks, including the need for digital literacy, technological obstacles, and problems with motivation and engagement among students. For online learners to succeed, it is critical that institutions and educators address these issues and offer assistance. All things considered, online and remote learning have completely changed the face of education by providing flexibility, accessibility, and chances for lifetime learning and skill development in the current digital era[49, 50].

Proficiency in digital literacy and 21st-century skills is necessary for individuals to be able to explore, assess, and employ digital technologies in a variety of contexts within their personal, academic, and professional lives. The ability to effectively and ethically access, assess, use, and create digital information and resources is referred to as digital literacy. Digital literacy skills include the aptitude

for finding, assessing, and analyzing material from digital sources, such as webpages, databases, and online journals; the capacity to assess and evaluate media material critically in order to identify authenticity, bias, and reliability which includes text, photos, videos, and social media. the knowledge of social, legal, and ethical concerns surrounding the use of digital technology, such as online conduct, copyright, privacy and security; the capacity to use digital tools and platforms such as social media, video conferencing, messaging applications, and email to effectively communicate and collaborate; Fundamental competence with digital gadgets, software, and internet resources for word processing, spreadsheets, presentations, and web surfing, among other uses[51].

Critical thinking, problem-solving, and decision-making are among the 21st-century talents that are necessary for overcoming difficult obstacles and coming to wise decisions in the current digital environment. These abilities include information analysis, evidence evaluation, pattern recognition, and problem-solving creativity. Innovation and creativity are highly sought-after 21st-century abilities that entail coming up with unique concepts, coming up with solutions, and thinking beyond the box to solve issues and take advantage of opportunities. These abilities are critical for promoting entrepreneurship, creativity, and career advancement in a variety of sectors. In the digital age, having strong teamwork and communication abilities is crucial for success. Using digital platforms and technologies, collaborative abilities entail sharing ideas, cooperating with others, and contributing to team objectives. Clear information transmitting, attentive listening, and productive conversation in digital and in-person settings are all part of communication skills. Flexibility and

adaptability are essential traits in today's world of rapid change because they help people deal with uncertainty, welcome change, and prosper in a variety of settings. These abilities entail being receptive to novel concepts, educational opportunities, and technological developments as well as flexible enough to adjust to changing conditions and obstacles[49, 51, 52].

Understanding and appreciating different viewpoints, cultures, and worldviews in a linked, digital world requires a global and cultural awareness. These abilities include encouraging inclusivity, appreciating and accepting cultural differences, and working well in multicultural environments. Integrity, empathy, and social responsibility in digital interactions and decision-making are all part of 21st-century abilities, which include ethical leadership and accountability. These competencies include maintaining moral standards, honoring the rights and dignity of others, and sensibly utilizing digital tools for the good of society. In general, digital literacy and 21st-century skills are critical proficiencies that enable people to prosper in the digital era, overcome difficult obstacles, and make constructive contributions to society at large. Through education, training, and chances for lifelong learning, these abilities can be fostered, enabling people to acquire the competences required to thrive and contribute positively in the quickly changing digital landscape of today[52].

An approach to teaching and learning known as "data-driven instruction" makes use of student data to customize learning activities, make better educational decisions, and raise student achievement. To evaluate the development and comprehension of their students, teachers gather a variety of data. Formative assessment results test scores, classroom observations, student work samples and

behavioral data are a few examples of this data. Instructors examine the gathered information to find trends, patterns, areas of strength, and areas where students' learning needs to be improved. Teachers can identify areas in which students may be struggling or performing well and modify instruction accordingly by looking at statistics on student performance[53].

Teachers establish quantifiable, realistic, and precise learning objectives for their students based on data analysis. These objectives are in line with curriculum goals, academic standards, and the unique needs and priorities of each student. To address identified areas of need and support students' learning objectives, teachers create focused instructional interventions and techniques. Differentiated instruction, small-group instruction, one-on-one tutoring, enrichment activities, and more practice chances are a few examples of these treatments. Teachers keep an eye on the performance and progress of their students at all times during the teaching process. Observations, exit tickets, quizzes, and class discussions are some of the continual formative assessment strategies they employ to determine how well students are learning and make necessary instructional adjustments. Based on their performance statistics, teachers give students timely and targeted feedback. Feedback enables students to identify their areas of strength and development, dispel misconceptions, and direct their own learning[52, 53].

Teachers modify their lesson plans to fit the changing needs of students based on data analysis and continuous observation. To better assist student learning and take into account individual learning preferences and styles, they could alter the tempo, content delivery, instructional strategies, or assessment techniques. Teachers share

data, insights, and teaching strategies with coworkers, administrators, and support personnel in a collaborative effort. Through collaborative data analysis, educators can enhance student results by exchanging best practices, gaining fresh views, and utilizing their collective experience. By establishing learning objectives, monitoring their own development, and engaging in reflective practice, educators engage students in the process of data-driven instruction. Students who feel empowered to take charge of their education are more motivated, accountable, and capable of self-control. Instructors assess the effects of their instructional tactics and interventions on the learning objectives of their students. They track students' progress towards learning objectives and make data-driven decisions about their future education using information from summative assessments, student performance data, and other sources. Teachers can address learning gaps, individualize instruction, and foster student achievement by adjusting instruction to the varied needs and skills of their students by putting data-driven instruction techniques into practice[54, 55].

To improve student learning outcomes over time, stay up to date on educational trends and best practices, and improve their teaching abilities, educators need to get professional development and assistance. Create communities of collaborative learning where teachers may exchange ideas, work together on instructional strategies and materials, and participate in peer-to-peer learning. Professional learning communities give educators a forum to talk about issues, share knowledge, and encourage one another's career development; provide a range of options for professional development, such as webinars, conferences, workshops, seminars, and online courses; give teachers the chance to experiment with innovative

teaching strategies, cutting-edge instructional technologies, and evidence-based practices that are pertinent to their subject areas and grade levels[56,57].In order to support educators in achieving their professional development objectives, it is important to acknowledge that they have a variety of learning requirements and preferences. Provide educators with individualized coaching, mentorship, and feedback based on their strengths, areas for improvement, and career goals. Incorporate professional development opportunities into educators' employment responsibilities and everyday work routines. Offer educators job-integrated coaching, observations, and feedback to assist them in putting new teaching strategies into practice and integrating what they have learned into their everyday teaching. Encourage peer observation and feedback as a form of professional development. Encourage educators to share their teaching strategies, visit other educators' classrooms, and offer helpful criticism in order to foster a culture of trust and cooperation that will enhance ongoing professional development. Enable teachers to take on leadership positions and projects in their districts or schools. Offer chances for curriculum design teams, teacher-led professional development, action research projects, and other leadership opportunities where educators may share their knowledge and effect change[57, 58].

Provide assistance and training to ensure that instructional technology tools and resources are successfully integrated into the classroom. To encourage educators in exploring new technologies, gaining digital literacy skills, and utilizing digital tools to improve teaching and learning, offer practical courses, demonstrations, and continuing support. To assist educators in establishing inclusive and culturally

sensitive learning environments, offer professional development focused on equity-centered practices and culturally responsive pedagogy. Provide instruction on how to deal with implicit prejudice, advance diversity, equity, and inclusion, and help every kid succeed academically. Motivate teachers to practice reflection as a way to advance their careers. Give teachers formal opportunity to evaluate their methods, examine student data, pinpoint areas that need work, and establish goals for their own professional development. After professional development sessions, provide educators with continuing support and advice to make sure they have the tools, direction, and resources they need to successfully apply new strategies. To assist effective implementation in the classroom and to reinforce learning, offer resources, coaching, and mentorship in the form of follow-up. Schools and districts may cultivate a culture of quality, innovation, and continual improvement in teaching and learning by providing professional development and support for educators. This will ultimately benefit students and enhance educational results[54, 59].

2.1.3.1 Google Classroom

Google Classroom is a digital learning platform developed by Google that enables teachers to create, manage, and deliver instructional materials, assignments, and assessments to students in a virtual classroom environment. Google Classroom offers educators a flexible and easy-to-use platform to support instruction in both traditional and online learning settings. Teachers may design collaborative, dynamic, and interesting learning experiences that support students' success by utilizing the platform's features and capabilities. Coordinating and collaborating effectively is

crucial in every situation, including schools, which calls for streamlined communication. Teachers can simplify communication by centralizing all announcements, messages, and updates in one location by using a centralized communication platform, like Google Classroom. Parents and children may now more easily obtain crucial information without having to sort through several channels thanks to this. Platforms for streamlined communication frequently provide instant notification capabilities that notify users in real time of any new announcements, messages, or assignments. This guarantees prompt correspondence and facilitates stakeholders' awareness of significant occurrences, due dates, and updates[60, 62].

Clarity and conciseness are prerequisites for effective communication. Teachers can provide instructions, announcements, and messages that are easier for parents and children to comprehend and adhere to by using streamlined communication platforms. Teachers, students, and parents may communicate with each other in both directions thanks to streamlined communication tools. This makes it simple for stakeholders to exchange comments, queries, and clarifications, encouraging communication and cooperation. Streamlined platforms frequently facilitate document sharing and

Collaboration tools in addition to text-based communication. Instructors can collaborate on editing, feedback, and revision with students and parents by sharing documents, presentations, and other materials. Communication threads are better organized with the use of streamlined platforms, which also make it simple to access

previous debates, announcements, and messages. By doing this, significant data is preserved and made easily available for future use[63].

Simplified communication platforms provide a high value on security and privacy, guaranteeing the confidentiality and protection of sensitive data. Parents, teachers, and children can all safely communicate on the platform without having to worry about their privacy being violated or unauthorized access occurring. Platforms for streamlined communication are made to be easily accessible and practical for users. Communication threads are easily accessible to all parties at any time and from any location, as they are frequently compatible with a variety of devices, such as computers, tablets, and smart phones. Parental involvement in education is facilitated by streamlined communication, which gives parents regular updates and insights into their child's behavior, performance, and academic achievement. This encourages openness, participation, and cooperation between educators and careers. Teachers can save time and effort by simplifying communication instead of juggling several platforms and methods. This enables them to concentrate more on organizing, facilitating, and teaching students' learning. More efficient communication benefits instructors, students, and parents by fostering collaboration, transparency, and participation in learning environments. Teachers can establish a cohesive and encouraging learning environment that fosters both academic achievement and student well-being by skillfully utilizing communication tools[63, 64].The term "assignment management" describes the systematic and effective process of generating, allocating, gathering, evaluating, and giving feedback on assignments. To monitor student progress, give timely feedback, and evaluate learning objectives,

teachers must manage assignments effectively. Instructors design assignments that support curriculum standards, instructional goals, and learning objectives. Numerous tasks, including essays, projects, tests, presentations, and problem-solving activities, can be included in assignments. Each assignment has a set of explicit instructions, expectations, and formatting requirements from the teacher. There are also assessment criteria and deadlines. Ensuring that students understand expectations and how their work will be judged is ensured through clear communication[65]. Assignments are sent to students by teachers using a variety of media, including email, Learning Management Systems (LMS), in-person instruction, and online resources like Google Classroom. Depending on the instructional approach, assignments may be distributed as digital files, links to internet resources, or hard copies. Instructors keep tabs on assignment status in order to assess student development and make sure that due date are fulfilled. This could entail keeping track of assignments turned in, monitoring student participation, and identifying those students who might require more help or guidance. Students use the approved submission mechanism to turn in their completed assignments by the deadline. This could entail sending work by email, turning in hard copies in class, or uploading files to a website. Instructors grade student work according to predetermined standards and offer comments to help students learn and get better. Assessments can be scored, written replies examined, project results evaluated, or feedback based on a rubric can all be part of the grading process[65, 66].

To assist students in understanding their areas of strength and growth as well as how they are progressing towards their learning objectives, teachers offer timely

and helpful feedback on assignments. Feedback can be given verbally or in writing, through annotations, audio files, or in-person conversations. Instructors keep track of assignments, grades, and comments from students for administrative needs and to help with instructional decision-making. This can entail maintaining attendance logs, student work portfolios, and grade books either paper or electronic. In order to encourage openness and responsibility, teachers let parents and students know about assignment requirements, due dates, and comments. This could entail using email, web portals, or parent-teacher conferences to send out updates, progress reports, and reminders. In order to accommodate the various requirements and skill levels of their students, teachers modify, extend, and accommodate assignments. Differentiation techniques can involve changing the difficulty of the work, offering more resources for support, or presenting alternate options for assessment. Planning, organizing, and communicating well are essential to effective assignment management because it guarantees that students obtain valuable feedback and experiences that advance their academic progress. Instructors may boost student enthusiasm, engagement, and accomplishment in the classroom by putting effective assignment management strategies into practice[60, 67].

Effective teaching and learning requires organization and file management, especially in digital learning contexts. Files should be arranged into folders and subfolders according to subjects, units, or subject matter. Make it simple for instructors and students to find particular resources by giving folder names that are clear and understandable. To make sure that files are clearly recognizable and searchable, establish a consistent file name convention. To add context and clarity,

include pertinent details in the filename, such as the subject, date, and topic. For easy visual identification of various file kinds or categories, apply color coding. To help with resource identification and organization, use distinct colors for assignments, presentations, handouts, and exams. To make finding and filtering easier, add keywords, labels, or tags to files using the tagging and metadata capabilities. Add pertinent keywords or descriptions to files in order to better organize them and make them more accessible[68].

Clearly labeling distinct file versions (e.g., v1, v2, final) will help you keep track of updates and revisions while maintaining version control. This keeps things clearer and guarantees that visitors are viewing the most recent versions of the documents. To safely store and arrange files, use cloud storage services like Drop box, Microsoft One Drive, and Google Drive. These systems come with functions like automated device synchronization, folder sharing, and teamwork. Examine software and tools for organization created especially for teachers, such as classroom management platforms or Learning Management Systems (LMS). These tools frequently have functions for handling assignments, keeping track of resources, and promoting student collaboration. Plan routine file maintenance sessions to examine, tidy, and purge folders and files. To maintain a neat and effective digital workspace, archive old materials, remove unnecessary or outdated files, and update folder structures as needed[69].

Establish backup mechanisms to guard against losing data and guarantee file security. Regularly backup essential files, and use access limits and encryption to protect sensitive data. Educate and assist educators and learners in efficient file

organization techniques. Provide instructions to users on how to efficiently traverse the digital learning environment by organizing files, utilizing digital tools, and resolving typical problems. These techniques can help teachers establish a productive and orderly digital workspace that facilitates instruction, learning, and teamwork in both brick-and-mortar and virtual learning settings. In the end, efficient file management improves learning for both students and teachers by fostering productivity, accessibility, and effective communication[68, 69].

Many advantages are offered to administrators, teachers, and students by integrating with Google Workspace, formerly known as G Suite for Education. A range of collaboration and productivity solutions, like Google Workspace, are available to improve teaching and learning in both traditional and virtual learning settings. Multiple users can work together in real-time on documents, spreadsheets, and presentations using Google Docs, Sheets, and Slides. Teachers and students can collaborate and actively participate by creating, sharing, and co editing assignments, projects, and instructional materials. For the purpose of storing, organizing, and sharing information and resources, Google Drive offers safe cloud storage. Google Drive allows teachers to save lesson plans, student work, multimedia resources, and instructional materials so they can be accessed from any internet-connected device[70].

Google Workspace provides tools for communication and teamwork, including Gmail, Calendar, Meet, and Chat. In order to encourage participation and connectedness, educators can arrange meetings, hold virtual classes, contact with parents, students, and coworkers, and lead conversations. Google Classroom allows teachers to create and distribute assignments, give feedback, and evaluate student

work all within the platform. It connects easily with other Google Workspace tools. This increases workflow efficiency and simplifies assignment management. Google Workspace technologies facilitate the process of giving feedback and evaluating student work. Google Docs, Sheets, and Slides annotations, comments, and suggestions allow teachers to monitor changes, provide students tailored feedback, and gauge their understanding. Numerous learning management systems provide connection with Google Workspace, including well-known ones like Moodle and Canvas. This makes it possible for teachers to integrate Google Drive files, calendar events, and collaboration capabilities straight into the Learning Management System (LMS), giving both teachers and students a smooth user experience[70, 71].

To guarantee that instructional materials are accessible to all students, including those with disabilities, Google Workspace has built-in accessibility tools, keyboard shortcuts, and screen reader support. Google Workspace places a high priority on data security and privacy, following stringent privacy laws and offering strong security measures to safeguard private data. Teachers maintain authority over who can see and distribute files, protecting student information. Google provides training materials, support services, and resources for professional development to help teachers make the most of Google Workspace products in the classroom. This includes community forums, certification programmes, and online training courses for exchanging troubleshooting and best practices. Google Workspace for Education is a cost-effective way to undertake technology-enhanced teaching and learning initiatives since it provides educational institutions and schools with free and reasonably priced pricing plans. Google Workspace integration gives teachers access

to a robust toolkit of materials and technologies that improve teamwork, communication, productivity, and creativity in the classroom. Teachers may design dynamic and captivating learning experiences that foster student success and achievement by skillfully utilizing Google Workspace[72].

Real-time collaboration refers to the ability for multiple users to work together simultaneously on a shared document, project, or task, with changes and updates reflected instantly for all participants. Real-time collaboration tools facilitate synchronous communication and teamwork, allowing users to collaborate effectively regardless of their physical location. Multiple users can edit the same document, spreadsheet, or presentation simultaneously with real-time collaboration features. The instantaneous visibility of modifications made by a single user facilitates smooth cooperation without requiring manual version control or file sharing. All devices and users involved in the collaboration receive real-time updates and synchronization of any modifications or additions made by their collaborators. This guarantees that everyone in the team always has access to the most recent version of the document[70, 72].

Chat or message features that enable collaborators to exchange ideas while working together are frequently integrated into real-time collaboration platforms. This eliminates the need for separate communication channels and allows for real-time feedback, conversation, and decision-making. A revision history of the document, containing all user modifications over time, is tracked and maintained by the majority of real-time collaboration solutions. This enables contributors to follow the document's development, go back and examine previous edits, and revert to earlier

versions as needed. Users can easily collaborate from anywhere, at any time, with real-time collaboration tools because they are normally accessible from any device with an internet connection. Teams may collaborate remotely, even when they are in various time zones and places thanks to this flexibility. Cross-platform compatibility is a feature of many real-time collaboration tools, which allows users to access and utilize them on a range of hardware and operating systems, including PCs, tablets, and smartphones. This guarantees that everyone on the team, irrespective of their preferred device, may take part in the collaboration[69, 70].

Teams can move from collaborative document editing to job assignment, project tracking, and workflow management with ease thanks to the integration of some real-time collaboration technologies with project management software. This improves productivity and simplifies project coordination. Real-time collaboration facilitates an interactive and collaborative work atmosphere where team members may exchange ideas, work through issues together, and make choices in unison. This encourages originality, inventiveness, and efficiency, which improves output and project results. For telecommuting and remote work, real-time collaboration solutions are very helpful since they enable distributed teams to work together productively even when they are not physically close. This makes it possible for businesses to take advantage of talent that exists anywhere in the globe and adjust to evolving work environments. In educational settings, real-time collaboration tools are also frequently employed to support group projects, peer editing, and cooperative learning activities. Together, they can complete tasks, exchange ideas, and give immediate feedback all of which improve student engagement and academic results. In contemporary work

situations, real-time collaboration solutions are essential for facilitating smooth communication, teamwork, and productivity among various teams and settings. Organizations and individuals can achieve increased productivity, creativity, and success in their projects and endeavors by properly utilizing real-time collaboration[70, 71, 72].

Assessment and feedback are integral components of the teaching and learning process, providing valuable information to both educators and students to gauge progress, identify strengths and weaknesses and guide instructional decisions. The process of assessment entails obtaining proof of students' learning and accomplishments in order to assess their knowledge, abilities, and comprehension of the course material. There are many different ways to assess someone, such as through tests, exams, projects, presentations, and performance activities. Throughout the learning process, formative assessment is used to track students' progress, spot misconceptions, and give prompt feedback to inform instruction. Formative assessments assist teachers in modifying their teaching tactics to better suit the requirements of their students. They can be informal (such as exit tickets, class debates) or formal (such as quizzes, homework assignments) [73].

Summative assessments are used to evaluate the learning outcomes and accomplishments of students at the conclusion of a unit or course. Summative evaluations, which might take the shape of exams, final projects, portfolios, or standardized tests, offer a thorough picture of students' work. Students receive feedback regarding their performance, development, and areas for growth. Specific, constructive, and actionable feedback that emphasizes both areas of strength and

areas in need of improvement is what makes it effective. Feedback can be given verbally, in the form of written remarks, in the form of rubric-based evaluations, or in the form of self-assessment reflections. Giving students timely feedback is crucial to fostering their learning and development. When feedback is given soon after an assessment, it gives students the chance to review what they learned, correct any misunderstandings, and improve their performance. Differentiated feedback acknowledges the range of learning needs and preferences among students. In order to optimize learning outcomes, teachers customize feedback based on each student's strengths, limitations, and preferred learning style[74, 75].

Peer feedback is when students give their classmates comments on the work they have done. Peer feedback teaches students how to constructively critique and analyze one other's work, which fosters teamwork, critical thinking, and communication skills. Students can define learning objectives, track their progress, and think back on their educational experiences with the aid of assessment and feedback. Students can take charge of their learning process and acquire metacognitive abilities when they are encouraged to establish goals, monitor their progress, and reflect on what they have learned. A key component of feedback literacy is teaching students how to provide, receive, and act upon feedback. Teachers assist students in gaining the knowledge and abilities necessary to evaluate feedback, pinpoint areas in need of development, and take initiative to better their learning. A culture of continual development in teaching and learning is supported by assessment and feedback. Instructors can enhance their teaching tactics and help students succeed over time by evaluating assessment data, considering comments, and modifying their

practices. Feedback and assessment are effective strategies for raising student motivation, engagement, and learning objectives. Teachers may establish safe, encouraging learning environments where every student can reach their potential by incorporating efficient evaluation procedures and offering insightful feedback[76].

Parent engagement is a collaborative partnership between parents, guardians, and educators to support student learning, development, and success. Strong parent engagement is associated with improved academic achievement, positive behavior, and overall well-being for students. Communication between educators and parents must be open and continuous in order to foster parent engagement. This could involve using email, newsletters, parent-teacher conferences, and communication applications to spread the word about the curriculum, activities in the classroom, student progress, and future events. When parents actively participate in their child's education and encourage learning outside of the classroom, it strengthens the bond between the home and the school. In addition to promoting reading and fostering a home environment that values education, parents can help their children retain academic concepts[58, 60].

Parental participation encourages parents to take an active role in their child's education. In order to encourage student success, educators incorporate parents in goal-setting, decision-making, and academic planning procedures. They also solicit their involvement and opinions. Teachers give parents tools, advice, and encouragement to help with learning at home. This could be helping with homework, making recommendations for educational activities, and endorsing websites or educational applications. Parent empowerment and education opportunities are a

common feature of parent involvement programmes. Parents might feel more confidence in their ability to support their child's development by attending workshops, seminars, and training sessions on subjects including reading, math strategies, and parenting techniques. Parent engagement promotes parental involvement in school-related events, activities, and volunteer opportunities. In addition to strengthening school-home ties and improving the general school atmosphere, this involvement creates a sense of community and belonging[77].

Parents that are actively involved in their children's education support school programmes aimed at raising academic standards for all students. They work together with educators, managers, and legislators to resolve issues, advance fairness, and push for supplies and assistance. Positive parent-teacher relationships built on mutual respect, trust, and open communication are enhanced by parent engagement. Collaborative efforts, problem-solving, and student support are facilitated by strong relationships between educators and parents. In order to acknowledge and thank parents for their contributions to their child's development, educators celebrate the accomplishments and advancements of their children. In addition to fostering a culture of celebration and recognition, parent appreciation events, award ceremonies, and celebrations serve to highlight the value of parent engagement. The goal of parent engagement programmes is to create solid family-school relationships that support the wellbeing and academic achievement of students. Parents and teachers may establish supportive settings where all students develop academically, socially, and emotionally by cooperating as partners in education. In an all-encompassing educational approach that emphasizes cooperation, communication, and partnership

between the home and the school, parent involvement is essential. Educators may establish motivating, supportive learning environments that encourage student accomplishment and success throughout life by cultivating strong parent participation[78].

The term "mobile accessibility" describes how easily digital products and services, including apps and content, may be accessed and utilized on portable electronic devices like tablets and smartphones. Making sure mobile is accessible is crucial to reaching a large audience and giving people who use mobile devices as their primary or only internet connection equitable access to tools and information. Responsive design strategies are used by mobile-friendly websites and applications to adjust to various screen sizes and orientations, making for the best possible viewing and interaction experience on mobile devices. Content is presented in a readable and clear manner on smaller displays thanks to responsive design, which also makes navigation components accessible and simple to use. Touch screen navigation strategies that support pinching, swiping, tapping, and multi-touch interactions are part of mobile accessibility. It is simpler for users to engage with material on mobile devices when interfaces are designed with large, touch-friendly buttons and controls. This is especially true for people who have dexterity or motor impairments[79].

Through the use of assistive technology, mobile accessibility guarantees screen reader compatibility, enabling people with visual impairments to navigate and engage with digital information. Screen readers can reliably interpret and communicate content to users when websites and applications are designed with semantic HTML, descriptive alt text for images, and appropriate labeling of form

fields. To improve reading and legibility on smaller displays, mobile accessibility takes into account text size, font style, and color contrast. When font size and contrast settings are customizable, people with low vision or reading issues can tailor the display to their requirements and preferences[71, 79].

Mobile accessibility guarantees that interactive features and digital material can be accessed and used with an external keyboard device or virtual keyboard. It is ensured that users may explore and interact with material without depending entirely on touch screen gestures by designing interfaces with interactive features and keyboard-friendly navigation. When it comes to mobile accessibility, captions, transcripts, and audio descriptions are all part of what makes audio and video material accessible to those with hearing or vision impairments. For users who are blind or visually impaired, audio descriptions provide visual information; transcripts and captions offer textual alternatives to spoken content. The wide range of mobile platforms (such as iOS and Android) and devices (such as smart phones and tablets) that users utilize is taken into account when discussing mobile accessibility[71]. Accessibility and usability are improved for all users when compatibility and consistent user experiences are maintained across various platforms and devices. The concept of progressive enhancement, which applies to mobile accessibility, states that all users should have access to essential features and content regardless of their device's capabilities or restrictions. Then, gradually adding advanced features and improvements, it ensures accessibility for all users while offering an improved experience for users with contemporary devices and browsers[80].

In order to detect accessibility hurdles and usability difficulties, mobile accessibility entails conducting usability testing and obtaining input from users with a variety of abilities and devices. Over time, iterative testing and improvement contribute to the increased accessibility and usability of mobile applications and content. In order to guarantee that digital content and apps fulfill accepted accessibility criteria and best practices, mobile accessibility conforms to established accessibility rules and standards, such as the Web Content Accessibility Rules (WCAR) and the Mobile Web Best Practices. Organizations can guarantee that their offerings are inclusive, egalitarian, and accessible to all consumers, irrespective of their device preferences or abilities, by giving mobile accessibility top priority during the design and development process of digital content and applications[81].

2.1.3.2 Flipped Classroom

Flipped Classroom is an instructional strategy that flips the conventional teaching model by having students undertakes assignments outside of class and using class time for discussions, active learning, and idea application. Using technology to optimize instruction delivery, foster engagement, and improve learning outcomes, the flipped classroom model offers a student-centered, active learning approach. Teachers may build dynamic and engaging learning environments that enable students to take charge of their education and achieve academic success by flipping the standard teaching model. Pre-class instruction is the term used to describe the educational resources and exercises that students undertake prior to attending a class session. An

essential part of the teaching strategy in a flipped classroom is pre-class instruction[41, 43].

Pre-class training usually consists of a variety of tools and materials intended to present new ideas to students, give background knowledge, and present topics before the actual class meeting. Teachers record quick video lectures that cover important subjects and include clarifications, examples, and demonstrations. Students can watch these videos online via different digital platforms or a Learning Management System (LMS). The context, justifications, and supplemental material for the topics that will be presented in class are supplied by assigned readings from textbooks, journals, or other sources. Interactive online tutorials, modules, and presentations provide students with interesting multimedia content, interactive activities, and simulations to enhance their learning and idea exploration. Student understanding can be evaluated and areas for more review can be identified through pre-class practice tasks, quizzes, or self-assessment activities[44,46].

Pre-class instruction materials are usually made available to students ahead of the planned class period so they can review the content whenever and wherever they choose, at their own leisure. Students can interact with the material in a way that best suits their unique learning requirements, schedules, and preferences because to this flexibility. Students who get quality pre-class education are more likely to participate actively, think critically, and reflect. Students are urged to actively engage with the resources, make notes, pose inquiries, and consider how well they comprehend the ideas being covered. Preparing students for meaningful participation in class activities, debates, and concept application during the scheduled class period is the main goal of

pre-class instruction. Students who have familiarized themselves with the material ahead of time will be better able to contribute to class discussions, work cooperatively with classmates, and use their expertise to solve problems[43, 44].

Pre-class training frequently makes use of platforms and resources from educational technology to provide curriculum in an effective and efficient manner. Pre-class instruction and student participation are often facilitated by the use of digital assessments, interactive tutorials, online reading materials, video hosting platforms, and learning management systems. Pre-class training gives students the chance to independently examine, interact with, and preview the material before class, which is a crucial component of the flipped classroom concept. Teachers can maximize class time for active learning activities, group discussions, and concept application by front-loading the delivery of knowledge outside of the classroom. This will ultimately improve student learning outcomes and engagement[41, 46].

In a flipped classroom, the activities are planned so that students participate in cooperative learning, problem-solving exercises, active learning, and idea application throughout the scheduled class session. In order to help students apply the concepts they learned during pre-class education to real-world circumstances, classroom activities frequently feature hands-on application exercises. These exercises could be case studies, role-playing games, simulations, problem-solving exercises, or real-world examples. One of the main focuses of flipped classroom activities is collaborative learning. Students participate in cooperative learning activities, solve issues, share ideas, and explore concepts in small groups or pairs. Peer learning,

critical thinking, and communication skills are all encouraged in group conversations[82].

Peer teaching and peer feedback exercises can be included into classroom activities. Students will take turns presenting solutions, clarifying topics, and giving helpful criticism to their peers. Peer teaching builds a supportive learning community, encourages active engagement, and reinforces understanding. Instructors' help students participate in class activities by answering their queries, elaborating on ideas, and offering more details or examples as needed. Students can ask questions, voice issues, and have discussions with peers and the teacher during questions and answers sessions to better comprehend the subject matter. Students participate in active learning experiences through interactive exercises and problem-solving assignments that demand the use of critical thinking abilities, information analysis, and knowledge synthesis. These could include idea mapping exercises, group problem solving assignments, brainstorming sessions, or data analysis projects. Debate sessions or organized conversations on contentious subjects, complicated problems, or opposing viewpoints connected to the course material are examples of classroom activities. Discussions and debates foster the investigation of various points of view, argumentation abilities, and critical thinking[83].

Students can evaluate their comprehension, identify areas for growth, and create learning goals by reflecting on their experiences and engaging in metacognition through classroom activities. Engaging in reflective activities fosters in-depth learning, self-awareness, and self-regulation. Instructors evaluate students' comprehension through formative assessments, track their progress, and give timely

feedback to help students learn. Activities for formative assessment could be concept checks, surveys, polls, quizzes, or peer reviews. Flipped classroom activities are intended to foster active participation, group projects, critical thinking, and application of topics while efficiently utilizing class time to enhance comprehension and reinforce learning goals. During class, teachers can create dynamic and interactive learning environments that support students' development and performance by including them in meaningful activities[82, 83].

Student-centered learning is an instructional approach that places students at the center of the learning process, emphasizing their active participation, autonomy, and responsibility for their own learning. Students actively participate in the learning process through cooperative projects, inquiry-based assignments, problem-solving activities, and hands-on activities in student-centered learning. Students build their own understanding of concepts, establish connections, and apply knowledge in meaningful ways rather than passively taking in information from the teacher. Diverse learning requirements, interests, and strengths are acknowledged in student-centered learning. To meet the unique learning styles, interests, and speeds of each student, instruction is tailored to them and differentiated accordingly. Instructors provide students the freedom to follow their interests, research subjects that are relevant to their daily lives, and establish their own learning objectives[41, 82].

Through student-centered learning, students are given the tools they need to become self-directed learners and take charge of their education. It is urged of students to make decisions, create objectives, organize their coursework, track their development, and think back on their educational experiences. Teachers support

students in developing self-regulation abilities and metacognitive awareness by serving as mentors, facilitators, and guides. Peer engagement and collaboration are essential elements of student-centered learning. Students collaborate in groups, pairs, or teams to solve puzzles, talk about ideas, share thoughts, and gain knowledge from one another. In addition to fostering a sense of community and belonging in the classroom, collaborative learning builds social-emotional development, communication skills, empathy, and teamwork[43, 83].

The use of student-centered learning fosters critical thinking abilities by motivating learners to pose inquiries, scrutinize data, assess supporting details, and deduce rational conclusions. Project-based learning, problem-based learning, and discovery learning are a few examples of inquiry-based learning strategies that involve students in investigating open-ended questions, finding answers to practical issues, and undertaking research. Constructivist learning theories, which emphasize that students actively, develop their own understanding of the world through their experiences, interactions, and reflections, are the foundation of student-centered learning. Through practical experiences, experimentation, and reflection on their learning process, students build on existing information, draw connections, and generate meaning[41, 44, 82].

The significance of continuous evaluation and feedback for learning is emphasized by student-centered learning. Instructors give students immediate, targeted, and helpful feedback to help them learn, clear up misconceptions, and advance. Instead of concentrating only on summative evaluation of results, assessment practices emphasize formative assessment strategies that promote learning

advancement. In addition to encouraging the development of critical thinking, cooperation, communication, and self-regulation all crucial 21st-century skills student-centered learning also promotes student involvement, motivation, and ownership of the learning process. Teachers may empower students to become lifelong learners who are ready to flourish in a world that is always changing by designing learning environments that prioritize their needs and interests[46, 83].

2.1.4 Biology

Biology is the scientific study of living organisms and their interactions with the environment. It covers a broad range of subjects, including ecological dynamics and the composition and operation of cells[8]. The structure, activity, and behavior of cells are the fundamental building blocks of life are the subject of cell Biology. It covers subjects including cellular metabolism, cellular division, cellular communication, and organelles in cells. Genetics is the study of genetic diversity, inheritance, and genes in living things. It looks into how genes are produced and regulated, how features are passed down from one generation to the next, and how genetic mutations affect diseases and evolutionary change. Ecology is the study of how living things interact with their surroundings. It looks at things like population dynamics, ecology in communities, the composition and operation of ecosystems, and the movement of nutrients and energy within them[84,85].

The study of evolutionary Biology focuses on the mechanisms involved in evolution, such as genetic drift, natural selection, speciation, and mutation. It aims to comprehend how organisms are suited to their surroundings and how they have

changed and diversified over time. The study of physiology focuses on the systems and processes that keep living things alive. It looks into how living things react to both internal and external stimuli, maintain homeostasis, and control physiological processes. Studying anatomy involves examining how living things are put together and structured. It looks at the anatomy of many creatures, ranging from simple single-celled organisms to intricate multicellular ones, and how their structural makeup affects their ability to survive and perform functional roles[86].

Microorganisms, encompassing bacteria, viruses, fungus, protists, and archaea, are the subject matter of Microbiology education. Their anatomy, physiology, genetics, ecology, and functions in human health and illness are all examined. The study of plants, including their physiology, diversity, growth, reproduction, and structure, is known as botany. It includes a number of sub-disciplines, including taxonomy, ecology, physiology, and anatomy of plants[87].The study of animals, including their composition, behavior, ecology, evolution, and taxonomy, is known as zoology. It includes the investigation of various animal taxa, including vertebrates and invertebrates, as well as their functions within ecosystems. The preservation, management, and protection of biodiversity and natural resources are the focus of conservation Biology. In addition to addressing issues including habitat loss, pollution, climate change, and overexploitation, it aims to provide conservation and sustainable management solutions[88].

Cell Biology is the study of the composition, functions, and behaviors of cells, which are the basic units of life. Numerous aspects of cells, such as their structure, metabolism, division, and interactions with external stimuli, are all investigated**.** The

study of cell structure includes the cytoskeleton, plasma membrane, extracellular matrix, and organelles such as the nucleus, mitochondria, endoplasmic reticulum, Golgi apparatus, and lysosomes. The study of cell Biology focuses on the roles played by various organelles and parts of cells, including protein synthesis, intracellular transport, energy production (such as through cellular respiration) and cell signaling. The metabolic reactions that take place inside cells to sustain life are referred to as cellular metabolism. Cell Biology is the study of metabolic pathways that are involved in the synthesis of biomolecules and the conversion of nutrients into energy. Examples of these routes include glycolysis, the citric acid cycle, and oxidative phosphorylation. The set of processes that a cell goes through in order to divide and duplicate itself, is known as the cell cycle. Cell Biology studies how the cell cycle progresses (through interphase, mitosis, and cytokinesis), how cells divide (via mitosis and meiosis), and how the cell cycle is regulated[84, 89].

Cells replicate and divide to create new cells during cellular reproduction. The study of cell Biology focuses on procedures that are necessary for cellular development and reproduction, such as chromosome segregation, DNA replication, and cell differentiation. The study of cell Biology focuses on the processes that allow cells to exchange signals with one another. Cell signaling is the process by which signals (hormones, growth factors, neurotransmitters, etc.) are sent from the extracellular environment into the interior of the cell, resulting in gene expression and cellular reactions. The preservation of internal balance and stability in cells is known as cellular homeostasis. Cell Biology studies how cells respond to changes in their environment and manage their internal environment, pH, ion concentrations, and

osmotic balance. The study of cell Biology focuses on how cells interact with the extracellular matrix and with other cells in the vicinity. Organogenesis, tissue development, and cell communication are all greatly influenced by cell adhesion, cell junctions, and cell communication[90].

The study of cell Biology focuses on the movement, migration, and intracellular transport of individual cells. Cells may move, alter form, and interact with their surroundings in response to external cues and stimuli. The study of cell Biology focuses on how cells react to many types of stress, including environmental pollutants, oxidative stress, and DNA damage. Cells possess the ability to heal damage, initiate stress responses, and undergo programmed cell death, also known as apoptosis, as required. In order to comprehend the intricacies of life and the mechanisms underlying health and disease, a basic understanding of the structure, function, and behavior of cells is provided by cell Biology[84, 90].

The area of Biology known as genetics is devoted to the investigation of genes, heredity, and genetic diversity in living things. It covers a broad spectrum of subjects pertaining to the composition, operation, and inheritance of genes as well as their influence on the features and attributes of living things. The blueprints for creating and sustaining an organism are found in genes, which are units of heredity. Deoxyribonucleic acid, or DNA, is a double-stranded molecule that contains the genetic information required for the growth, operation, and reproduction of living things. Proteins are the building blocks of cells and carry out a variety of bodily tasks. Genes encode proteins. Genetic qualities are passed down from parents to their children through heredity. Genes are passed down from one generation to the next,

determining characteristics like height, eye color, and illness susceptibility. Scientists can better understand how features are inherited and how genetic variation develops throughout populations by studying heredity[91].

Based on the ideas put out by Gregor Mendel in the 1800s, Mendelian genetics describes how features are inherited in predictable ways. Mendel's rules of segregation and independent assortment explain the distribution of alleles, or distinct gene forms, during gamete creation as well as the expression of features in progeny. DNA, the genetic material that makes up eukaryotic cells, is housed in structures called chromosomes, which are located in the nucleus. They are essential for the transfer, replication, and storage of genetic information. Genes on chromosomes can show different patterns of inheritance from those outlined by Mendel. This phenomenon is known as chromosomal inheritance[92].

Variations in DNA sequences and allele frequencies within and between populations of organisms are referred to as genetic variation. Natural selection, genetic recombination, gene flow, and mutations all contribute to genetic variety, which is the building block of evolution and adaptation in living things. Genetic disorders are ailments brought on by mutations or anomalies in a person's genetic makeup. These conditions can be inherited from one or both parents and impact different areas of development and health. They can also arise spontaneously as a result of novel mutations. Huntington's disease, Down syndrome, sickle cell disease, and cystic fibrosis are a few examples of inherited illnesses. Numerous sectors, including health, agriculture, biotechnology, forensic science, and conservation Biology, have found use for genetics. Genetic technologies and research allow

scientists to create genetically modified crops and animals, study the genetic variety of species for conservation, do DNA analysis for forensic investigations, and diagnose and cure genetic illnesses. A basic area of Biology that sheds light on the evolution, variation, and inheritance of living things is genetics. It has profound effects on biodiversity, agriculture, human health, and our comprehension of the natural world[93].

Ecology is the scientific study of how living things interact with other living things, their surroundings, and both biotic and abiotic elements. It covers a broad spectrum of subjects pertaining to the distribution, quantity, and dynamics of living things as well as the patterns and mechanisms that form ecosystems. Ecology studies species and populations as well as communities, ecosystems, and the biosphere at various scales of organization. Different ecological study scales are represented by each organizational level, and interactions take place both within and across levels. Relationships between organisms and their biotic and abiotic surroundings are referred to as ecological interactions. Among the ecological interactions are symbiosis, mutualism, parasitism, competition, and predation. The distribution of species, population dynamics, and the structure and function of ecosystems are all impacted by these interactions[8, 94].

The study of organism populations, including their size, density, dispersion, rates of growth, and demography, is the main emphasis of population ecology. Population ecologists study immigration, emigration, birth rates, death rates, and environmental factors that affect population dynamics. The study of interactions between populations of various species within a given geographic area is known as

community ecology. It investigates trophic linkages, community structure, species interactions, and patterns of species diversity. Community ecologists study the effects of biotic variables on community dynamics, including mutualism, competition, and predation[85, 95].

The study of ecosystem ecology examines the relationships that exist between living things and the physical surroundings in which they live. It looks into the movement of energy, the cycling of nutrients, and the quantity and distribution of organisms within ecosystems. Ecologists that specialize in ecosystems study the composition, dynamics and functioning of ecosystems. The exchange of elements including carbon, nitrogen, phosphorus, and water between living things and the atmosphere, hydrosphere, lithosphere, and biosphere occurs through biogeochemical cycles. To comprehend the flow and modification of nutrients throughout ecosystems and their impact on ecosystem functions, ecologists research biogeochemical cycles[94, 95].

The process by which populations of organisms adapt over time to environmental changes or shocks is known as ecological succession. Whereas secondary succession develops after disturbances that eliminate preexisting vegetation, primary succession takes place on recently developed or bare substrates. Over time, succession causes changes in the distribution of species, the organization of communities, and the evolution of ecosystems. The field of ecology known as conservation Biology is dedicated to managing and preserving ecosystems and biodiversity. Threats to biodiversity, the effects of human activity on ecosystems, and methods for preserving and reintroducing species and habitats are all areas of research

for conservation ecologists. Ecology is essential to comprehending how natural systems work, forecasting the consequences of environmental change, and guiding conservation and management initiatives. It offers insightful information on the intricate relationships that exist between living things and their surroundings as well as the mechanisms that keep life on Earth going[88, 89, 96].

The area of Biology known as "evolutionary Biology" focuses on the patterns and processes of biological evolution, including the emergence, diversification, and adaptation of living things across time. It covers a broad spectrum of subjects pertaining to the processes of evolution, the origins of life on Earth, and the patterns of biodiversity found in the natural world. The fundamental idea of evolutionary Biology is Charles Darwin's hypothesis of evolution, which was put forth in the 19th century. It claims that natural selection, which affects heritable variation within populations, causes species to change throughout time. The mechanisms of evolution, including as natural selection, genetic drift, gene flow, mutation, and speciation, are studied by evolutionary biologists. Natural selection is the process by which people possessing qualities better suited to their surroundings have a higher chance of surviving, procreating, and transferring their favorable features to subsequent generations, through the process of natural selection, modifications that improve an organism's fitness and raise its chances of surviving and procreating in its surroundings gradually accumulate[95, 96].

The process through which organisms gradually adapt to become more suitable to their surroundings is known as adaptation. Adaptations result from natural selection acting on heritable variation within populations. These variations might be

physical, physiological, behavioral, or ecological. Through adaptations, organisms are able to endure and procreate within their designated ecological niches. The foundation of evolution and adaptation is genetic variety. It speaks about variations in allele frequencies and DNA sequences both within and between populations of organisms. Natural selection can operate on genetic variation because it results from several genetic processes such as gene flow, genetic recombination, and mutations. The process through which new species diverge from preexisting ones is known as speciation. Genetic variations accumulate that preclude interbreeding when populations grow reproductively isolated from one another. Different methods can lead to speciation: parapatric speciation (partial isolation), sympatric speciation (non-geographic isolation), and allopatric speciation (geographic isolation). The study of evolutionary links between species, based on similarities and differences in their physical, genetic, and behavioral traits, is known as phylogenetic. Using techniques like molecular phylogenetic, cladistics, and comparative genomics, phylogenetic analyses reconstruct the evolutionary history (phylogeny) of organisms[92, 93].

Macroevolution is the term used to describe patterns and processes of evolution that take place at or above the level of species and result in the long-term diversification of life forms. It covers the emergence of large groups of creatures (e.g., mammals evolved from reptiles), mass extinctions, adaptive radiations, and the emergence of new species and higher taxonomic categories. There are real-world uses for evolutionary Biology in the domains of biotechnology, conservation Biology, agriculture, and medicine. It contributes to our knowledge of pesticide resistance, disease resistance, breeding programmes, conservation tactics, and the creation of

new medications and treatments. A thorough framework for comprehending the origins, diversity, and complexity of life on Earth is provided by evolutionary Biology. It tackles important issues such the beginnings and development of species, the processes behind evolutionary change, and the patterns of biodiversity found in the natural world[97,98].

The area of Biology known as physiology examines the workings and mechanisms of living things including all of their constituent organs, tissues, cells, and organ systems. It covers a broad spectrum of subjects pertaining to the mechanisms that allow living things to carry out their basic functions, preserve homeostasis, and react to external stimuli. Cells are the fundamental structural and functional elements of living things, and the study of their functions and activities is the main focus of cell physiology. It looks into how energy is produced, how cells move across membranes, how they signal to one another, and how they communicate.Organs are collections of cells with comparable morphology and function that cooperate to carry out particular activities. Tissue physiology studies the roles and interactions of these tissues. Nervous, muscular, connective, and epithelial tissues are a few types of tissues. The study of tissue physiology aims to understand the role that tissues play in the overall health of organs and organ systems[99].

Organ physiology is the study of how the body's organs, which are made up of various tissues arranged to carry out particular tasks, work. The heart, lungs, kidneys, liver, brain, and digestive system are a few examples of organs. Organ physiology studies the integrated interactions between organs within organ systems as well as the structure and function of individual organs. Organ systems are collections of organs

that cooperate to carry out intricate physiological processes essential to the organism's existence. Organ system physiology studies these relationships and their activities. The circulatory, respiratory, digestive, neurological, endocrine, and immunological systems are a few examples of organ systems. Living things respond to changes in their external environment by utilizing the process of homeostasis to preserve internal stability and equilibrium. Various physiological parameters, including blood glucose levels, pH balance, blood pressure, body temperature, and fluid balance, are regulated by physiological systems to maintain them within ideal ranges for regular cellular activity. Physiology studies how various organ systems work together to sustain homeostasis and promote the general well-being and functionality of the body. The respiratory system supplies oxygen for cellular respiration, the urine system eliminates metabolic waste products from the body, and the circulatory system supplies oxygen and nutrients to tissues[100].

Physiology investigates the regulatory systems that sustain homeostasis and regulate physiological functions. These systems encompass brain regulation, autonomic regulation, feedback loops, hormone regulation, and physiological reactions to external stimuli. In practical contexts like medicine, exercise science, sports medicine, rehabilitation, occupational health, and environmental health, applied physiology utilizes the concepts of physiology. It aims to comprehend how health, disease prevention, performance, and quality of life may all be improved by applying physiological principles. The dynamic and multidisciplinary study of physiology combines concepts from Biology, chemistry, physics, and medicine to comprehend the basic functions of living things and their environments. It offers a

basis for clinical practice, teaching, and research in a range of scientific and medical domains[99, 100].

2.1.5 Genetics

The area of Biology known as genetics is dedicated to the investigation of genes, heredity, and genetic diversity in living things. It covers a broad spectrum of subjects, including the genetic foundation of traits and illnesses as well as the molecular mechanics of heredity. DNA segments known as genes are blueprints for constructing proteins, which are the fundamental constituents of all cells and tissues. Certain characteristics, such blood type, eye colour, and disease susceptibility, are inherited from one's parents. Cells have structures called chromosomes that house genetic material. Human chromosomes are present in the nucleus of each cell and are inherited in pairs, one from each parent. Several genes are found on each chromosome[91, 101].

The molecule that contains all living things' genetic information is called deoxyribonucleic acid, or DNA. Two lengthy strands that have been twisted into a double helix configuration make up DNA. The genetic code is made up of the nucleotide bases adenine, thymine, cytosine, and guanine arranged in a certain order along the DNA molecule. The differences in DNA sequences among members of a population or species are referred to as genetic variation. Genetic variation is the foundation of biodiversity and evolutionary change, resulting from genetic recombination, gene flow, and mutations. Mendelian genetics, so named in honor of Gregor Mendel, the scientist, explains how certain patterns of gene transmission determine how traits are inherited. Classical genetics is based on Mendel's theories of

inheritance, which include the laws of segregation and independent assortment. Breeding experiments involving the crossing of organisms with known genotypes in order to investigate the inheritance of particular features are known as genetic crosses. Punnett squares and other genetic tools are used to examine inheritance patterns and forecast the results of genetic crossings[92, 102].

Genetic disorders are illnesses brought on by changes or anomalies in chromosomes or genes. Huntington's disease, Down syndrome, sickle cell anemia, and cystic fibrosis are a few examples of hereditary illnesses. The process of modifying an organism's genetic makeup through technological methods is known as genetic engineering. It encompasses methods to change genes for a variety of applications, including biotechnology, agriculture, and medical research, including gene cloning, recombinant DNA technology, and gene editing (e.g., CRISPR-Cas9). The study of genetic diversity and evolution within populations is known as population genetics. In order to comprehend how populations evolve over time, it looks at elements such allele frequencies, genetic drift, gene flow, natural selection, and genetic adaptability. The study of genetic diversity and inheritance in humans is the main focus of human genetics. It looks at the genetic underpinnings of human behaviors, diseases, and traits as well as the genetic influences on ancestry and population diversity. Genetics has applications in forensic science, medicine, agriculture, conservation Biology, and other fields. It is essential to understanding the mechanisms of heredity, evolution, and illness[103].

The fundamental elements of heredity that hold the instructions needed to create and maintain organisms are called genes. These are sections of

deoxyribonucleic acid, or DNA, found on chromosomes in cell nuclei. These are sections of DNA (deoxyribonucleic acid) found on chromosomes in the nucleus of cells. Proteins are the building blocks of cells and tissues, and genes carry the instructions needed to synthesize them. In the body, proteins carry out a variety of tasks, such as forming structural support, initiating chemical reactions, and acting as signaling molecules. The fundamental building blocks of DNA, nucleotides, are the units of sequence that make up genes. Adenine (A), thymine (T), cytosine (C), and guanine (G) are the four nitrogenous bases that make up each nucleotide, along with a phosphate group. The genetic code is the arrangement of these bases along the DNA molecule[101, 103].

During reproduction, genes are transferred from parents to offspring. Genetic variation occurs within populations as a result of offspring inheriting one copy of each gene from each parent. Mendelian inheritance, comprising the laws of segregation and independent assortment, governs how genes are passed down from one generation to the next. Alleles are distinct variations of a gene that result from genetic recombination or mutations. Variations in allele frequencies among populations account for genetic variation and can impact features like blood type, eye color, and illness susceptibility. The process by which the data contained in genes is utilized to create functional proteins is known as gene expression. There are two primary phases involved: transcription, which converts the DNA sequence into messenger RNA (mRNA), and translation, which converts the mRNA into the precise amino acid sequence needed to build a protein. To make sure that genes are activated or inactive in the appropriate cells at the appropriate times, gene expression is strictly

controlled by a number of processes. Promoter, enhancer, and transcription factor are examples of regulatory elements that regulate the specificity and pace of gene transcription[93, 103].

The entirety of an organism's genes or genetic material is called its genome. It consists of non-coding DNA segments that control gene expression and support the structure and function of the genome in addition to the coding DNA portions known as exons, which encode proteins. Genetic disorders are ailments brought on by abnormalities or dysfunctions in particular genes, and mutations in those genes can cause these disorders. Huntington's disease, Down syndrome, sickle cell anemia, and cystic fibrosis are a few examples of hereditary illnesses. Genes are essential for determining an organism's features and attributes, as well as how susceptible it is to illnesses and external influences. To fully comprehend the intricacies of genetics and its consequences for health, evolution, and biodiversity, one must have a solid understanding of the structure, function, and control of genes[104].

Chromosomes are structures found in the nucleus of eukaryotic cells that contain genetic material in the form of DNA (deoxyribonucleic acid). They are essential for the transfer, replication, and storage of genetic information. DNA molecules are coiled around proteins known as histones to form the long, thread-like structures known as chromosomes. During cell division, the DNA-protein complex undergoes additional coiling and condensing to create a compact structure that is observable under a microscope. Within the cell nucleus, chromosomes make sure that lengthy DNA molecules are neatly arranged and packed. This packing guarantees proper chromosomal segregation during cell division, aids in DNA replication and

transcription, and helps shield DNA from harm. Different creatures have distinct chromosomal counts and shapes. For instance, the 46 chromosomes in humans are arranged into 23 pairs. One chromosome from the mother and one from the father make up each pair of chromosomes. The most prevalent forms of chromosomes are acrocentric, telocentric, metacentric, and sub-metacentric. Chromosomes can also be categorized according to their shape[91, 92,104].

A pair of chromosomes known as homologous chromosomes has the same genes at the same loci (locations), but the alleles (variants) of those genes may differ. Each parent passes on a homologous chromosome, which recombines genetically during meiosis to produce genetic variation in progeny. A specialized area of the chromosome called the centromere is essential for chromosomal segregation during cell division. It acts as the attachment site for spindle fibers, which are in charge of separating the chromosomes throughout the processes of meiosis and mitosis. A chromosome that has two identical copies connected at the centromere is called a sister chromatid. During DNA replication, sister chromatids are created, and they stay together until they split apart during cell division. A karyotype is an image of a person's chromosomes grouped according to size and form. In genetics, karyotyping is frequently used to detect chromosomal abnormalities, such as structural defects or aneuploidy (abnormal chromosome number) [101,103,104].

Errors in chromosomal number or structure can lead to chromosomal disorders. Examples include translocations (the exchange of chromosomal segments between non-homologous chromosomes), trisomy (an additional chromosome), monosomy (a missing chromosome), and deletions or duplications of chromosomal

segments. The sex of an individual is determined by their sex chromosome in many species, including humans. Male humans have one X and one Y chromosome (XY), while female humans have two X chromosomes (XX). Inheritance of sex-related features and sexual development are significantly influenced by sex chromosomes. Chromosomes are fundamental biological structures that house the genetic material required for an organism's growth, development, and reproduction. The study of chromosomal structure and function is essential to the study of genetics and has consequences for biodiversity, evolution, and human health[104, 105].

Deoxyribonucleic acid, also known as DNA, is a molecule that houses the genetic instructions necessary for the growth, development, reproduction, and operation of all known living things as well as numerous viruses. The double-helix structure of DNA is like a spiral staircase or twisted ladder. It is made up of two lengthy nucleotide strands that are wound around one another. Adenine (A), thymine (T), cytosine (C), and guanine (G) are the four nitrogenous bases that are present in each nucleotide, together with a phosphate group and a sugar molecule (deoxyribose). Hydrogen bonding between complementary base pairs keep the two DNA strands together. Thymine (A-T) and guanine (C-G) are the pairings of adenine and cytosine. The accuracy of the replication and transcription of the two strands of DNA is guaranteed by this complimentary base pairing[92, 105].

The genetic code, which carries the instructions for constructing proteins, is formed by the arrangement of nucleotide bases along the DNA molecule. DNA segments known as genes are composed of particular nucleotide sequences that either code for proteins or control the expression of other genes. The process by which a cell

copies its DNA exactly once prior to cell division is known as DNA replication. The two DNA strands unwind and split apart during replication, with each strand acting as a template for the production of a new complimentary strand. Two identical DNA molecules, each made up of one original strand and one freshly synthesized strand, are the end product. The act of copying genetic information from DNA into an RNA (Ribonucleic Acid) molecule that is complementary is called transcription. The messenger RNA (mRNA) molecule transports genetic instructions from the nucleus' DNA to the cytoplasm's ribosomes, which are responsible for protein synthesis. The process of assembling proteins using the genetic information carried by mRNA is called translation. The building blocks of proteins, amino acids, are matched with the sequence of codons groups of three nucleotides on the mRNA by ribosome during translation[91,101,105].

The genetic information that defines an organism's features and attributes is found in its DNA. Variations in the nucleotide sequence of DNA emerge from mutations, genetic recombination, and other genetic processes. These variations account for genetic variety. Genetic information is handed down from one generation to the next through the transfer of DNA during reproduction from parents to children. Because offspring receive genetic material from both parents, there is a greater genetic variation among populations. Numerous industries, including biotechnology, forensic science, agriculture, and medicine, have used genetic engineering and DNA technologies. With the use of methods like Polymerase Chain Reaction (PCR), DNA sequencing, and gene editing (like CRISPR-Cas9), scientists can investigate DNA, identify genetic diseases, change genes, and modify organisms for a variety of uses.

The amazing molecule known as DNA is the blueprint for life; it contains the instructions necessary for the growth, functionality, and diversity of all living things. Deciphering DNA's function in genetics is crucial to understanding life's intricacies and expanding our understanding of Biology and biotechnology[101, 104,105].

The area of genetics known as "human genetics" is devoted to the investigation of trait variation and inheritance in human populations. It covers a broad spectrum of human Biology-related subjects, including as population genetics, genetic disorders, the structure and function of human genes, and the underlying Biology of complex features and diseases. The principles of Mendelian inheritance, which explain how features are passed down from parents to offspring through gene transmission, are the foundation of human genetics. Mendel's laws of segregation and independent assortment can be applied to the inheritance of traits such as blood type, eye colour, and genetic illnesses. Genetic disorders are problems brought on by anomalies or mutations in a person's genetic makeup. Human genetics studies these conditions. These conditions might arise spontaneously as a result of novel mutations or they can be inherited from one or both parents. Human genetic illnesses include sickle cell disease, Huntington's disease, Down syndrome, and cystic fibrosis[103].

The study of genetic variation and evolutionary processes within human groups is known as population genetics. It looks at things like population structure, genetic diversity, allele frequencies, and the impact of natural selection, genetic drift, and mutation on human genetic variation. The study of human genetics aims to understand the genetic foundation of complex traits and disorders that are impacted by several genes and environmental circumstances. Complex diseases and qualities

include things like height, IQ, diabetes, cancer, heart disease, and diabetes. It is common practice to employ Genome-Wide Association Studies (GWAS) to find genetic variations linked to complex traits and illnesses[93, 105].

A branch of human genetics called "medical genetics" is concerned with the identification, treatment, and management of hereditary diseases and genetic disorders. Medical geneticists diagnose and treat genetic abnormalities and offer guidance to individuals and families impacted by genetic conditions using methods like genetic testing, genetic counseling, and gene therapy. A number of ethical, legal, and social concerns are brought up by human genetics research, including those pertaining to genetic discrimination, privacy, consent, access to genetic testing and treatments, and the effects of genetic technologies on people as individuals, families, and society as a whole. In addition to addressing these issues, ELSI research seeks to provide guidance for laws and rules governing the ethical use of genetic data. The study of human genetics is essential to the advancement of our knowledge of human Biology, illness, and health. Human geneticists support medical research, personalized medicine, genetic counseling, and public health programmes that strive to enhance human health and well-being by examining the genetic foundation of features and disorders[105].

2.2 Theoretical Framework

2.2.1 Social Learning Theory

The psychologist Albert Bandura developed the Social Learning Theory, which emphasizes the value of social interaction and observation in the learning process.

Bandura's theory states that in addition to firsthand experiences (such rewards and punishments), people also learn via observing the actions of others and the outcomes of those actions[106]. Social learning theory claims that learning is the result of dynamic interactions between behavioral, cognitive, and environmental factors. The Social Learning Theory places a strong emphasis on the value of modeling or vicarious learning, another name for observational learning. People pick up knowledge through imitating the actions of others, such as media characters, parents, instructors, and classmates, and by modeling their own behavior after those observations. The mechanisms of attention, memory, reproduction, and motivation all play a role in observational learning. Modeling is copying actions that one has seen and found to be gratifying or encouraging in others. People tend to emulate the actions of influential persons or role models when such actions result in favorable consequences. Modeling can take place in a variety of settings, such as the media, peer groups, schools, and families[107, 108].

The Social Learning Theory recognizes that rewards and penalties have an impact on behavior. People are more prone to mimic actions that bring rewards or reinforcement than they are to mimic actions that bring consequences or lack of reinforcement. Reinforcement can come from internal sources like self-satisfaction or self-esteem or external sources like praise or awards. The cognitive functions of learning, such as cognitive processing, memory, and attention, are highlighted by social learning theory. People selectively pay attention to, remember, and encode information about behaviors they watch. Later, when the time is right, they recall and replicate those behaviors. Social Learning Theory heavily relies on self-efficacy, or

views about one's own competence and capacity to complete particular activities. People are more inclined to act in ways they think they can carry out effectively and less likely to act in ways they think they cannot. Past experiences, social persuasion, vicarious experiences, and physiological conditions are some of the elements that affect self-efficacy. In general, social learning theory emphasizes how social interaction, observation, and modeling play a significant role in influencing behavior and thought processes. Teachers may design learning settings that support the development of self-efficacy and adaptive behaviors, offer chances for observational learning, and encourage positive role modeling by grasping the fundamentals of social learning theory[109, 110].

The mental operations involved in gathering, analyzing, storing, and retrieving information are referred to as cognitive processes. These mechanisms are fundamental to human cognition and behavior, affecting how people see, comprehend, and engage with their environment. A vast array of mental functions is included in cognitive processes, such as perception, learning, problem-solving, reasoning, and decision-making. The cognitive process of selectively focusing on some elements of the environment while disregarding others is referred to as attention. It enables people to focus their mental energies on pertinent stimuli and block out distractions. Perception, learning, and memory formation all depend heavily on attention. Interpreting sensory data from the surroundings to produce a meaningful understanding of the world is the process of perception. It includes functions including feeling, identifying patterns, and interpreting sensory information. People

may successfully navigate the world and make sense of their surroundings thanks to perception[111].

Information is encoded, stored, and retrieved cognitively over time through memory. It includes encoding, storing information throughout time, and retrieving information from storage when needed. It also involves the development of new memories. For the purposes of learning, making decisions, and solving problems, memory is essential. Learning is the process of picking up new information, abilities, attitudes, or behaviors by training, experience, or observation. It includes behavioral or cognitive alterations brought on by experience. Numerous processes, including as conditioning, observation, and active interaction with the environment, can lead to learning. The cognitive process of coming up with answers to challenging or unknown situations is known as problem-solving. It entails determining objectives, coming up with potential fixes, weighing options, and deciding on the best course of action. Critical thinking, creativity, and metacognitive techniques are necessary for problem-solving. The cognitive process of reasoning involves generating conclusions or inferences based on data, reasoning, and past knowledge. It entails applying both inductive and deductive thinking to solve issues and arrive at logical conclusions. Critical thinking, problem-solving, and decision-making all heavily depend on reasoning[106, 112].

The cognitive process of choosing a plan of action from a variety of options is known as decision-making. It entails assessing the available options, calculating the possible results, and deciding on the best course of action in light of restrictions, goals, and preferences. Emotions, the environment, and cognitive biases all affect how

decisions are made. The cognitive process of reflecting on one's own thoughts is known as metacognition. It entails being conscious of and in charge of one's cognitive processes, which include organizing, supervising, and assessing learning tactics. Through metacognition, people may control how they learn, evaluate what they've learned, and modify their approaches to maximize their learning results. Human perception, learning, reasoning, and decision-making in a complex and dynamic world are all influenced by cognitive processes, which are fundamental to human cognition and behavior. Learning about these processes can help shape educational strategies, cognitive therapies, and psychological theories of human behavior by shedding light on how people learn, solve issues, and interact with their surroundings[113, 114].

The confidence one has in one's ability to complete a task or achieve a certain goal is referred to as "self-efficacy," and it was first used by psychologist Albert Bandura. It is essential to motivation, behavior, and achievement and is a fundamental part of social cognitive theory. Self-efficacy is a measure of a person's belief in their own capacity to carry out tasks, resolve issues, and achieve objectives. It is predicated on evaluating one's own competencies, aptitudes, and prior experiences. Task-specificity refers to the fact that self-efficacy changes based on the specific task or activity. Depending on their degree of experience, knowledge, and talent in particular areas, a person may feel confident in their abilities to complete some activities but less confident in others[106, 112,115].

People's decisions, efforts, and perseverance in the face of difficulties are all influenced by their sense of self-efficacy. High self-efficacy people are more inclined

to establish ambitious objectives, put forth effort, and perseveres in the face of adversity. Four primary factors affect self-efficacy beliefs: Mastery experiences: Confidence and self-efficacy beliefs are strengthened by prior triumphs and accomplishments; Vicarious experiences: By offering a role model for imitation and inspiration, witnessing others accomplish a task effectively can boost one's own self-efficacy; Social persuasion: Support, criticism, and encouragement from others can increase beliefs in one's own abilities; Physiological and emotional states: By affecting perceptions of ability, physical sensations (such as arousal, exhaustion), as well as emotional states (such as anxiety, stress), can have an impact on self-efficacy[113,116].

Beliefs in one's own efficacy have a big influence on motivation, output, and success. High self-efficacy people are more likely to establish difficult objectives, keep going in the face of setbacks, and succeed. On the other hand, low self-efficacy might cause people to shy away from difficult jobs, put in less effort, and do worse. Self-efficacy beliefs can be strengthened and improved in a number of ways, such as: - By offering chances for skill development and mastery experiences. Giving supportive, upbeat, and encouraging remarks; Offering positive role models and instances of accomplished work; Offering stress, anxiety, and self-doubt management techniques. Self-efficacy is a potent psychological concept that affects behavior, accomplishment, and motivation. People can succeed in many areas of life, overcome challenges, and pursue ambitious objectives by cultivating a sense of confidence and belief in their own skills[117].

The flipped classroom method and Google Classroom's features allow educators to design a setting that reflects Social Learning Theory's tenets: Through group projects, peer reviews, and live streaming, students get to see the ideas, effort, and viewpoints of their classmates. Students who collaborate on projects, share resources, and offer feedback are modeling these behaviors for their peers. Students modify their own educational experiences by applying fresh concepts, methods, and viewpoints to their own productions. In conclusion, teachers can establish an engaging and productive learning environment that encourages critical thinking, collaboration, and deeper learning by integrating the flipped classroom method with Google Classroom's features and Social Learning Theory principles[117].

2.2.2 Active Learning Theory

The theory of active learning places significant emphasis on the role that learner involvement, participation, and interaction play in the educational process. The theory suggests that active learning is more effective for students than passively absorbing knowledge from textbooks or professors. Building on the ideas of constructivist and social learning theories, active learning theory supports learner-centered strategies that foster critical thinking, problem-solving, and a deeper knowledge. The theory of active learning places significant emphasis on involving students in the learning process by means of practical exercises, dialogues, collaborative projects, and real-life scenarios. Students are motivated, their curiosity is piqued, and they are encouraged to take charge of their education through active learning activities. Students are encouraged to participate and interact actively

according to the active learning approach. Students are urged to interact with their peers, exchange ideas, and ask questions instead than just taking in material passively. This encourages students to build their own understanding through conversation and engagement in a dynamic learning environment[47, 118].

Constructivist learning theories, which highlight the role of students as active architects of knowledge, are closely related to active learning theory. Constructivism holds that learning is a process of meaning-making that happens when students actively interact with their surroundings. Students can build their own understanding, draw connections between new and prior information, and apply concepts in meaningful contexts through active learning activities[119].The principle of active learning encourages students to enhance their critical thinking abilities by pushing them to examine, assess, and synthesize knowledge. Through problem-solving and critical thinking, students engage in active learning tasks that demand informed decision-making. Students who participate in active learning activities enhance their critical thinking abilities and improve their ability to learn and solve problems[120].

A vast array of teaching techniques and exercises, such as role-playing, group discussions, cooperative learning, case studies, simulations, and problem-based learning, are all included in the active learning philosophy. Through these exercises, students can interact with the material, communicate their thoughts, and show that they understand it in a variety of ways. In order to improve student learning, active learning theory emphasizes the value of giving feedback and creating opportunities for reflection. Students can track their development, pinpoint areas for growth, and modify their learning tactics with the support of feedback. Students are encouraged to

think meta-cognitively about their learning objectives, methods, and process through reflection. Active learning theory encourages a method of teaching and learning that is focused on the needs of the individual student, enabling them to actively interact with the material, work together with their peers, and create their own conceptual frameworks. Teachers may create dynamic, engaging learning environments that support critical thinking, deeper learning, and student achievement by putting active learning principles into practice[47, 121,122].

Making rational decisions or judgments requires the cognitive process of critical thinking, which includes information analysis, evaluation, and synthesis. It is a crucial ability that allows people to solve complicated problems, evaluate arguments and supporting data critically, and reason logically. Beyond just learning facts by heart or taking information at face value, critical thinking is actively engaging with concepts, challenging presumptions, and carefully weighing the available data to draw well-informed judgments. In order to comprehend the significance and applicability of complicated knowledge, critical thinking entails disassembling it into its constituent components and looking at each one separately. This could entail looking for patterns, connections, or contradictions in the data and figuring out how they add to our knowledge of the subject as a whole. Evaluating the trustworthiness, validity, and credibility of sources, arguments, and information is a necessary part of critical thinking. This entails evaluating the quality of the arguments, the evidence, and any potential biases or presumptions that may be present in the data. People can assess information to ascertain its reliability and suitability for use in making defensible decisions[122, 123].

Interpreting information is a crucial part of critical thinking since it allows one to derive meaning and make conclusions. This could entail locating important themes, viewpoints, or implications in the data and weighing their importance in light of the analysis's overarching goal or the larger context. Making logical judgments or deductions based on information, logic, and available data is a key component of critical thinking. In order to do this, conclusions must be derived logically from the argument's premises or presumptions and supported by the available data. Since critical thinking helps people recognize, assess, and evaluate potential solutions to complicated situations, it is crucial for problem-solving. This could entail coming up with original ideas, taking into account multiple viewpoints, and analyzing the advantages and disadvantages of several possibilities before making a choice. Reflecting on one's own beliefs, biases, and thought processes is an essential part of critical thinking, which helps people become better reasoners and makes more informed decisions. Metacognitive techniques like self-monitoring, self-correction, and self-assessment may be used in this. For success in educational, professional, and personal settings, critical thinking is a fundamental ability. Critical thinking abilities can help people learn more effectively, solve problems more adeptly, and make better decisions by helping them make sense of complex situations and make well-informed decisions in a world that is changing quickly[124].

It is imperative to provide students with a varied range of learning activities in the classroom to foster active learning, sustain student engagement, and accommodate varying learning styles and preferences. Traditional lectures still have a place, but they can be made more interesting by adding interactive features like polls,

discussions, and questions. It can also be beneficial to keep students' attention and reinforce important concepts to break up lectures with quick exercises or demonstrations. Encourage students to take part in class discussions, whether in small or large groups, to discuss, explore, and exchange viewpoints. Discussions in groups offer chances for critical thinking, cooperative learning, and the sharing of various points of view. Give your students opportunity to apply their academic knowledge to real-world circumstances or case studies. Through case studies, students are forced to think critically, assess issues, and weigh the pros and disadvantages of various options. Give students open-ended tasks or challenges to complete that call for creativity, critical thinking, and problem-solving abilities. Activities for addressing problems can be done alone or in groups, and they can include a variety of subjects and fields[123, 125].

To assist students in visualizing abstract concepts and comprehending scientific principles in action, do practical experiments, demonstrations, or simulations. Concrete experiences from hands-on activities improve learning and recall. Involve students in simulation games or role-playing situations that let them assume various personas, consider opposing viewpoints, and make decisions in a virtual setting. Role-playing exercises help develop decision-making, empathy, and perspective-taking abilities. Arrange deliberations on contentious subjects or topics to promote critical thinking, reasoning, and persuasive communication abilities. Students can examine opposing points of view, assess the validity of the evidence, and formulate well-founded arguments through debates[124,126].

To evaluate students' comprehension, gather comments, and encourage active engagement during lectures or presentations, use interactive quizzes or polling tools. Tests and surveys can be used to review content, measure understanding, and start conversations. Give students the task of instructing their peers on a subject or presenting a topic, either in groups or individually. Peer teaching activities give students the chance to practice speaking and presenting themselves in front of others, strengthen their understanding, and encourage active learning. Assign creative assignments that let students show, in unique ways, how they grasp subjects. Examples of these projects include research papers, multimedia presentations, artwork, and performances. Creative endeavors provide intrinsic motivation, autonomy, and self-expression. Teachers may engage students with a range of interests and skill levels, accommodate different learning styles, and create a dynamic, interactive learning environment that fosters deeper learning and student achievement by implementing a variety of activities into their lessons[127,128].

An essential part of the learning process that promotes students' development, self-awareness, and ongoing progress is reflection and feedback. They give students the chance to get advice, evaluate their development, and get a deeper comprehension of ideas and abilities. Give prompt, detailed, and useful feedback that emphasizes both your strengths and your room for development. Specific feedback helps define expectations and direct future performance, while timely feedback enables students to make necessary modifications and corrections right away. Feedback should be given in a positive and supportive way, focusing more on effort and a growth mentality than on predefined skills or grades. Urge students to see criticism and judgment as less

appropriate than seeing it as a chance for growth and learning. Provide summative feedback at the conclusion of a task or unit to assess overall performance and gauge student achievement, as well as formative feedback, which happen during the learning process to inform and support student growth. Adjust feedback to each student's unique requirements, preferences, and learning preferences. Give each student individualized feedback that takes into account their particular skills, weaknesses, and objectives. You should also provide alternate methods of feedback, such as written, spoken, or multimedia. Promote self- and peer-evaluation as supplementary sources of feedback. While peer assessment fosters metacognition, self-reflection, and self-regulated learning, self-assessment allows students to obtain insights into their own work, practice critical evaluation skills, and learn from one other[47, 129].

Students should be encouraged to reflect on their own learning experiences, tactics, and thought processes through metacognitive reflection. Encourage your students to reflect on what they have learned, how they have learnt it, and how they can learn better in the future. To support students' reflective processes and encourage more in-depth thinking, pose questions or provide cues. Students should be encouraged to consider the methods and techniques that have helped them learn as well as their own strengths, shortcomings, accomplishments, difficulties, and opportunities for improvement. To encourage active participation and accountability, include structured reflection exercises in your classes, assignments, and evaluations. Journaling, exit tickets, learning logs, and reflective essays are a few instances where students can record their ideas, realizations, and educational experiences. Students

should be encouraged to make clear, attainable goals based on their reflections and the input they have received. Assist students in identifying their areas of weakness and creating plans of action to overcome them. Setting goals fosters self-efficacy, motivation, and accountability while offering a structure for continuous self-directed learning. Teachers can encourage students to take charge of their education, cultivate metacognitive abilities, and aim for academic achievement by including feedback and reflection into their teaching and learning strategies. A culture of learning that prioritizes introspection, development, and lifelong learning is fostered by feedback and reflection[130, 131].

Teachers can create a more engaging and productive learning environment by incorporating the ideas of active learning into conventional teaching practices. Incorporating activities that encourage student engagement, cooperation, critical thinking, and reflection can enhance traditional teaching approaches like lectures and direct instruction. In addition to being in line with the principles of active learning theory, this hybrid approach makes use of the advantages of both active learning and traditional teaching techniques to raise academic achievement and student engagement[131].

2.3 Review of the Empirical Studies

2.3.1 Gender and Academic Achievement in Genetics

A study examined the impact of the Concept Mapping Instructional Strategy Combined with Discussion Web on the Academic achievement of Navrongo Senior High School students in the topic of genetics in general, as well as on the basis of

gender. Quasi-experimental design (pretest, posttest non-equivalent design) was used in the study. Eighty science students from Navrongo Senior High School's Form Three Gold Track and Green Track made up the sample. A control group and an experimental group were allocated to students from the Gold Track class and the Green Track class, respectively. Twenty female students and twenty male students made up the experimental group class. There were 24 men and 13 women in the control group class as well. Every participant received an administration of the pretest. Discussion Web and Concept Mapping Instructional Strategy were used to teach the experimental group. The conventional teaching method was used to instruct the control group. To assess the treatment's efficacy, a posttest was given to each group. Test-retest reliability coefficient was used to assess the test items' dependability. For the pretest- posttest, the instruments' test-retest reliability coefficients were determined to be 0.70 and 0.73, respectively. The t-test was used to examine the collected data[132].

The pretest test results showed that the students' Academic achievement was homogeneous (t-value = 1.05, p-value = 0.30, p>0.05). The experimental group's posttest results showed a significant difference from the control group (t-value = 8.07, p-value = 0.000, $p < 0.05$). The posttest results demonstrated that teaching genetics using idea mapping and discussion webs was a more successful approach than traditional teaching methods. In the experimental group, there was no statistically significant difference between the academic achievement of male and female students (t-value = 1.68, p-value = 0.11, $p > 0.05$)[132].

The teaching and learning of genetics could undergo a significant transformation if Information and Communication Technology (ICT) is incorporated. The study looked into how two secondary schools in the Kitwe, District integrated ICT into the teaching and learning of genetics. The aim of the research was to determine the impact of incorporating ICT as an adjunct to conventional teaching and learning methods on the attitudes and performance of students and instructors in the field of genetics in two secondary schools chosen from the Kitwe area. A mixed technique approach (concurrent triangulation design) was employed in the investigation. Pre- and post-test techniques, questionnaires, focus groups, interviews, and other approaches were used to gather both qualitative and quantitative data for the study. The 2 X 2 design analysis served as a guide for the thematic analysis of focus group and in-person interview data, as well as the quantitative analysis of student questionnaires and pretest and posttest results[133].

The results demonstrated that using ICT tools in genetics instruction and learning resulted in a considerable improvement in student performance. The findings also indicated a significant difference in the genetic performance of the experimental groups and the control groups according to gender and group names. Nonetheless, there was no statistically significant variation in genetic performance among the various student age groups. The use of ICT in genetics was seen well by both students and teachers, with average attitude mean ratings falling between 4.5 and 5.5. The findings also demonstrated how instructors' and students' views regarding the use of ICTs in genetics education were adversely impacted by ICT knowledge and skills, inadequate ICT infrastructure, a lack of ICT training, and restricted access to ICT[133].

A study investigated gender disparities in Biology retention, academic achievement, and senior secondary school students in Ekiti State. The research used an ex post facto design. Six schools provided 240 SS 2 students for the sample. Three theories were developed and put to the test at the significance level of 0.05. Statistics utilizing the independent t-test were used to examine the data. The findings indicated that there is a significant difference between the achievements means scores of male and female students[134].

The primary goal of a research was to determine how students' demographic characteristics affected their Biology Academic achievement in public secondary schools in Cross River State's Calabar Municipality Local Government Area. The dependent variable represents the students' Academic achievement in Biology, while the independent variables look at the students' demographic characteristics, such as gender, age, and birth order. Three research questions and three research hypotheses, respectively, were developed and posed to help the study reach its goal. A review of the literature was conducted using the study's variables. Ex-post facto research design was chosen for this investigation. For this study, two hundred and twenty (220) SS2 Biology students from public secondary schools were chosen at random. The researcher-created Biology accomplishment test served as the data collection tool. The first hypothesis was tested using an independent t-test statistic, while the second and third hypotheses were tested using an ANOVA statistical tool. Every hypothesis was examined at the 0.05 level of significance[135].

The study's conclusions showed that, in the Calabar Municipality Local Government Area of Cross River State, Nigeria, SS 11 Biology students' academic

achievement was significantly influenced by their gender, age, and birth order. The study's results and conclusions led to the recommendation that school officials periodically host seminars aimed at educating students on the significance of Biology and the impact of demographic factors. This will encourage students to study Biology and help them establish a positive attitude towards the topic[135].

In secondary schools in Rivers State, a study looked into how Web Quest and the 5E learning cycle affected students' performance in genetics. The study was led by three aims and three research questions, with three null hypotheses being evaluated at the 0.05 level of significance. A non-equivalent, quasi-experimental control group design was used in the investigation. Through the use of purposive sampling, three coeducational private schools were selected. Seven thousand two hundred and thirteen (7,213) students made up the study's population, from whom 96 Senior Secondary two (SS2) students were selected as a sample. Three intact classes were used.. The Genetics Performance Test (GPT), which of fifty (50) multiple-choice questions customized for the study, was the tool used to gather data. Six specialists affirmed this. Using Kuder-Richardson formula 21, the internal consistency was ascertained, and a reliability coefficient of 0.98 was found. In order to address the study questions, the collected data were analyzed using the mean and standard deviation. Analysis of Covariance was used to test the hypotheses at the 0.05 level of significance (ANCOVA)[136].

The study's findings showed that webQuest and the 5E learning cycle had a significant effect on students' performance in genetics. On the performance of both male and female students taught genetics, there was no significant interaction effect

of the 5E learning cycle and webQuest. The results of this study led to the recommendation that, in order to improve student performance, genetics classes should use web Quest and the 5E learning cycle[136].

2.3.2 Google Classroom and Academic Achievement in Genetics

These days, using technology apps in the classroom is very vital. As a result, one of the primary goals of the government's Jalinan Digital Negara (JENDELA) (2020–2022) strategy is to emphasize home learning. In addition, the Digital Educational Learning Initiative Malaysia (DELIM), a virtual learning platform, has been made available to schools by the Ministry of Education Malaysia under the name Google Classroom. However, traditional learning continues to be a prerequisite for the widespread use of economic teaching and learning methodologies. The current approach runs counter to both the needs of the current generation Z, which emphasizes self-directed learning, and constructivist learning. The goal of this study was to determine how Google Classroom-assisted learning affected economics students' Academic achievement. Pre- and post-achievement exams were used in this quasi-experimental study to gather information on 207 Form Six economics students using random cluster sampling[137].

Results showed that there was little difference between students in the experimental group who were exposed to the collaborative method (GCDK) and those who were not (GCTK and KPK); that is, With a value of F = 1.455, sig. = 0.236 ($p>0.05$), the ANCOVA test results indicate no significant difference in post-student accomplishment based on learning methodologies (GCDK, GCTK, and KPK). In order to collect more comprehensive data, it is advised that aspiring researchers speak

with a greater number of students at universities that provide matriculation and diploma-level economics courses. This study encourages educators to reconsider their previous approaches to instruction and to adopt a more flexible mindset in order to accommodate the resources and preparedness of today's students to engage with the digital learning environment, which is the new standard[137].

Determining the impact of students' use of Google Applications in Social Studies on their perceptions and academic achievement is the goal of this research. It attempted to respond to the following queries: (1) the degree to which students are satisfied with their use of Google Classroom, Google Meet, and Google Forms for their social studies classes; (2) the average level of the students' Academic achievement in social studies classes, as measured by recitation, performance tasks, and written assignments; and (3) the noteworthy impact of using Google Applications on the Academic achievement of the chosen Grade 7 students in social studies classes. In this study, the descriptive method was employed in order to answer the hypothesis based on the observations. Random sampling was employed by the researcher. One hundred (100) Grade 7 students from Pedro Guevara Memorial National High School served as the study's responders. In the third quarter of the academic year 2020–2021, this study was carried out. To find out how satisfied students were with Google Applications, a self-made questionnaire was created and used to collect data. Pre- and post-tests were employed by the researcher to assess how Google Applications affected the students' academic achievement in Social Studies. Following the acquisition of the data, the researcher presented, evaluated, and interpreted it[138].

The Google Classroom received an overall mean of 3.45 (Very Satisfied), Google Forms received an overall mean of 3.31 (Somewhat Satisfied), and Google Meet received an overall mean of 3.41 (Very Satisfied). The students expressed satisfaction with the use of Google Applications. The fact that these applications are inexpensive, easy to use, and user-friendly satisfied the students. Additionally, it was discovered that the use of Google Applications had a "significant effect" on the academic achievement of the chosen Grade 7 students in learning Social Studies, as measured by pre- and post-test results. The claim that using Google Applications has no significant effect on the academic achievement of the chosen seventh-grade students in their social studies classes is not supported[138].

This study examined the impact of Google Classroom on the Academic achievement of computer education students in South-South Education Colleges in Nigeria. The study was guided by five objectives, three research questions, and hypotheses. The study used a quasi-experimental pretest-posttest control group design. 571 NCE II computer education students from the eight state-owned Colleges of Education made up the study's population. Using a purposive random sampling technique, 110 NCE II Computer Education students from two intact classes during the 2021–2022 academic years made up the sample; The "Operating System Achievement Test" (OSAT) was the instrument created by the researcher for the study. Three specialists from the University of Uyo in Uyo face validated the instrument draft. To determine the instrument's reliability, a test-retest protocol was used. Thirty computer education students who were not included in the study sample or schools were given the instrument. Using Pearson Product Moment Correlation

(PPMC), a reliability coefficient of.82 was attained. In order to administer the equipment, the researcher briefed two course lecturers who worked as research assistants. Analysis of covariance (ANCOVA) was performed to test the null hypotheses at the.05 level of significance, whereas mean and standard deviation were utilized to answer research questions[139].

Findings of the study showed that there was a significant difference between the academic achievement scores of students taught an operating system through Google Classroom and those taught an operating system through Traditional Classroom; students taught using Google Classroom outperformed those taught in Traditional Classroom. The cognitive performance scores of students taught an operating system through Google Classroom and those taught it through Traditional Classroom, however, differ significantly, with the former grouping outperforming the latter. The mean retention scores of students taught operating systems through Google Classroom as compared to traditional classroom methods show a significant difference. It was suggested that universities should push instructors to use Google Classroom on a regular basis for certain subjects. Training on how to use Google Classrooms for instruction effectively should be provided to both lecturers and students[139].

2.3.3 Flipped Classroom and Academic Achievement in Genetics

The study examined the impact of Google Classroom-based flipped classroom training on the Academic achievement of secondary school students in the Onitsha educational zone in the subject of chemistry. The study was carried out at Anambra

State's Onitsha education zone. It was established how gender affected students' Academic achievement. Two hypotheses were evaluated at 0.05 alpha levels, and two research questions were posed to direct the investigation. A non-randomized control group design with pre- and post-tests was employed in a quasi-experimental research design. 3192 senior secondary year two chemistry students in the Onitsha education zone made up the study's population. Purposive and random selection approaches were used to choose 102 students for the sample. Additionally, two schools were selected as the experimental and control group centers using straightforward random sampling approaches. The Chemistry Achievement Test (CAT) was the tool used to collect the data. Two specialists from Nnamdi Azikwe University in Akwa, one in educational foundation and one in science education, validated the instruments. The Kudder-Richardson formula (K-R20), with an internal consistency of 0.82, was used to determine the reliability of CAT. The instrument was given to the respondent as a pretest and posttest in order to collect data for the study. The mean and standard deviation of the collected data were used to analyze the data and answer research questions, and analysis of covariance (ANCOVA) was used to test the null hypotheses[140].

The results revealed that there is a statistically significant difference in the academic attitude achievement of students taught chemistry using the FCIVGC method and those taught using the lecture approach, with the FCIVGC group performing significantly better. There is significant interaction effect of instructional approach and gender on students' achievement in chemistry. Based on this, FCIVGC favors both male and female chemistry students and is gender unbiased. Overall, the

research has demonstrated that Brame's FCIVGC is useful for raising chemistry achievement. It was determined that FCIVGC promotes a positive attitude in male chemistry students and is more successful in helping them attain academic success. It was suggested that educators use FCIVGC for instructing and learning chemistry[140].

In our digital age, studying through the use of contemporary technology is a must. Biology demands a special, technology-based learning approach because it is a science subject with special characteristics. Digital game-based learning and flipped classrooms is combined in the Flipped Classroom-Digital Game-Based Learning (FC-DGBL) learning model through assessments utilizing Kahoot digital game-based learning. Secondary school students enrolled in the grade nine bilingual programme were the subjects of this study on how the FC-DGBL learning model affected their conceptual grasp of genetics. The study was conducted in Jakarta, Indonesia, at Penabur Christian Secondary School Kelapa Gading. A 12-question essay test referencing Bloom's taxonomy was utilized to gather data on students' comprehension of genetic ideas in this quasi-experimental study, which involved 46 students. ANCOVA testing was used for the analysis, with a significance threshold of a = 0.05[141].

The findings demonstrated that FC-DGBL significantly improved bilingual secondary school students' conceptual grasp of genetics. Compared to students using conventional learning approaches, students who received the Flipped Classroom-Digital Game-Based Learning (FC-DGBL) greatly understood the idea of genetics. FC-DGBL showed a greater increase in the conceptual genetics understanding dimensions of applying genetic knowledge, analyzing the concept of genetics, and

proposing new ideas about genetics, while the control group showed a lower increase in the evaluation of genetics-related ideas. In bilingual learning programmes, FC-DGBL is an effective learning approach for genetics instruction[141].

This quasi-experimental study set out to find out how students with VAK learning styles in Gusau, Zamfara State, Nigeria performed academically in genetics when they received flipped classroom instruction and an improved lecture format. All Senior Secondary School 3 (SS 3) Biology students in Gusau made up the study population. One SS 3 intact class in each of the three randomly chosen schools was divided into three groups: experimental group 1 (n = 65), experimental group 2 (n = 58), and control group (n = 61). The Genetic Concepts Performance Test (GCPT) and the VAK questionnaire were the two tools used to gather data. Prior to the interventions, each class's students were grouped using a VAK questionnaire based on their preferences. While the control group received instruction in genetics via the traditional lecture method, experimental groups 1 and 2 received instruction using the enhanced lecture method and flipped classroom instruction, respectively. To assess academic achievement in genetics, the GCPT was used to deliver the pretest and posttest. The data was analyzed using the following methods: analysis of variance, mean, standard deviation, and parentage. Four weeks are allotted for the interventions[142].

The study found that the most popular learning styles among SS 3 students were visual (40.76%), auditory (31.52%), and kinesthetic (27.72%). Regardless of the VAK learning styles of the students, the study also discovered that flipped classroom instruction and improved lecture techniques led to better Academic achievement in

genetics when compared to traditional lecture approaches. For all learning styles, the flipped classroom approach proved to be the most successful, whereas the standard lecture method proved to be the least effective, particularly for kinesthetic learners. The study suggests that educators use these strategies while instructing Biology, especially when it comes to teaching genetics[142].

2.4 Conceptual Model

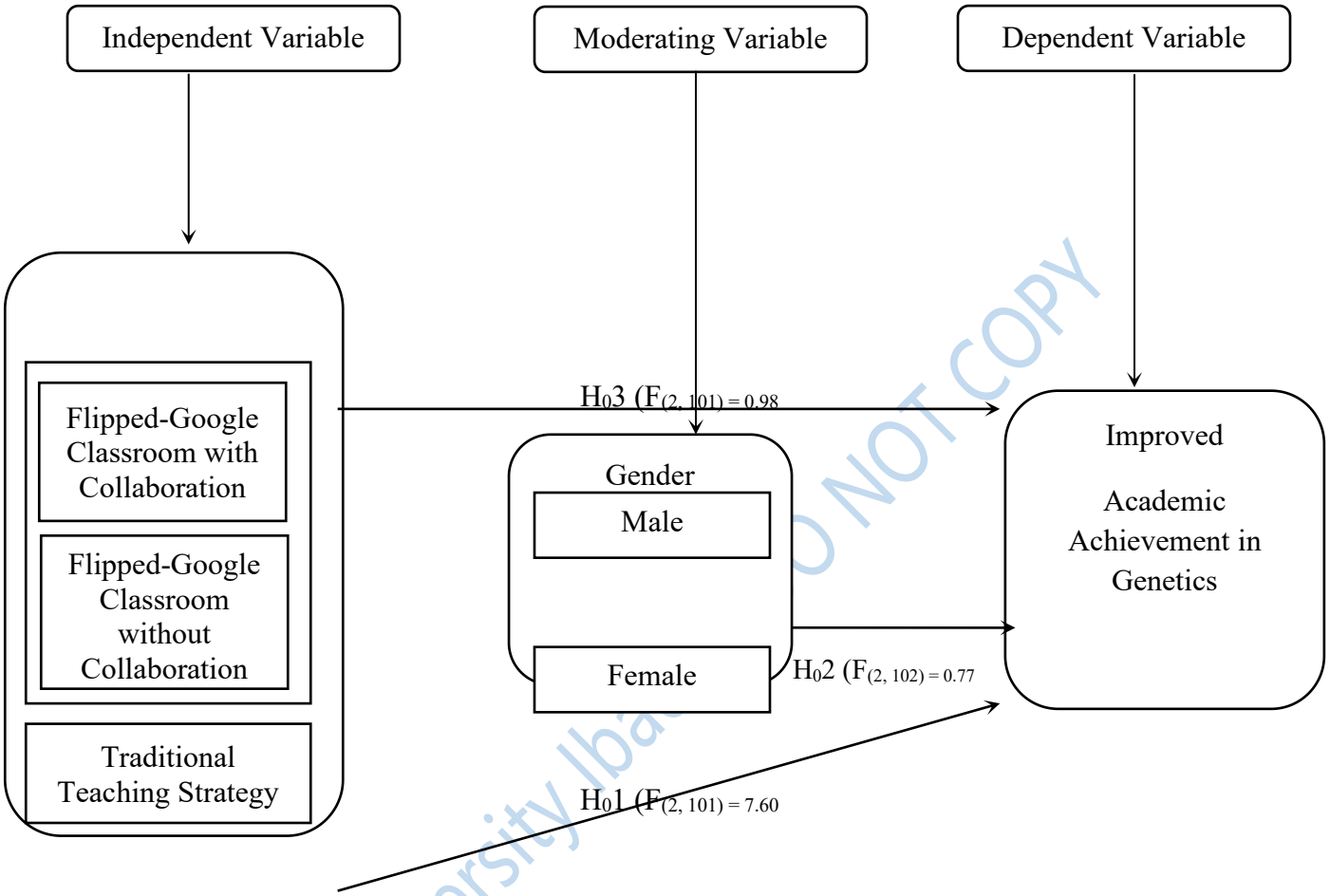


Figure 2.1: Conceptual Model of Digital Learning Platforms on senior secondary school students' academic achievement in Genetics

Source: *Researcher Fieldwork,* 2024

2.5 Summary of Literature Reviewed

This study conceptual review, explored factors influencing Academic Achievement, including teaching strategies, gender differences, and the use of technology in education. It examined the impact of gender on academic achievement, highlighting disparities and potential strategies for addressing gender-related issues in education. It investigated various instructional approaches and methods used to enhance learning outcomes, such as active learning, flipped classrooms, and technology integration. It discussed the use of Google Classroom as a digital learning platform and its potential effects on student engagement, collaboration, and academic achievement. It explored the flipped classroom model, which involves delivering instructional content online outside of class and using class time for active learning activities, and its impact on student learning and achievement. It provided an overview of key concepts and topics in Biology education, including genetics, Structure of Chromosomes, variation and Applications, and examined factors influencing student achievement in Biology.

The theoretical review examines how cognitive load affects learning and memory processes, and explores strategies for managing cognitive load to optimize learning outcomes. It focuses on the role of learners as active constructors of knowledge and the importance of hands-on, inquiry-based learning experiences in promoting understanding and retention. It investigates how social interaction, observation, and modeling influence learning behavior and outcomes, and explores implications for instructional design and classroom practices. It emphasizes the importance of student engagement and participation in the learning process, and

highlights the benefits of active learning strategies in promoting deeper understanding and critical thinking skills.

This study provided an overview of empirical studies examining gender differences in genetics achievement and explores factors contributing to gender gaps in performance. It summarized research investigating the impact of using Google Classroom as a digital learning platform on student achievement and engagement in Biology education. It evaluates the effectiveness of the flipped-google classroom model in genetics and its effects on student learning outcomes.

The conceptual model synthesized findings from the literature review to develop a framework for understanding the relationships between teaching strategies, technology integration, gender, and academic achievement in Biology education. It identifies potential factors influencing student success and proposes pathways for future research and practice in the field.

This summary provides a comprehensive overview of the literature review on each topic, highlighting key findings, trends, and areas for further investigation in Biology education.

Endnotes

1. A. Faiza, *Digital Learning Attributes And Students' Academic Achievement Among Pakistani Entrepreneurship Students: Mediating Role Of Student Engagement,***Journal of Advanced Research in Social Sciences and Humanities**, 7(3), 2022,95-107. Available online: https://doi.org/10.26500/jarssh-07-2022-0301.

2. E. Amiri& A. E. Karfa, *The Impact of Learning Environment on EFL Students' Academic Achievement: A study of Socio-Cultural Factors Affecting Academic Achievement*, **Arab World English Journal**, 12(4), 2021, 387–400.Available online: https://doi.org/10.24093/awej/vol12no4.25.

3. T. Z. Al Arif, *The Influences of Audio Visual Media And Vocabulary Mastery towards English Learning Achievement of EFL Students*, **J-SHMIC : Journal of English for Academic**, 7(1), 2020, 57–65. Available online: https://doi.org/10.25299/jshmic.2020.vol7(1).3905.

4. A. M. Juned, A. M. Faizah& S. M. S. Mustafa, *Performance Approach, Mastery Approach, Performance Avoidance and Mastery Avoidance as Predictors of Students' Academic Achievement in English, Mathematics and Science Subjects,***International Journal of Academic Research in Business and Social Sciences**, 10(11), 2020, 1150-1159. Available online: https://doi.org/10.6007/ijarbss/v10-i11/8190.

5. B. Nazrina, N. Amelia, M. Rejeni& A. Nyuak, *Machine Learning for Predicting Students' Academic Achievement based on Learning Style and Academic Results,***International Journal of Innovation and Industrial Revolution,** 5(15), 2023, 120–130. Available online: https://doi.org/10.35631/ijirev.515013.

6. B. Veli, Y. Topkaya& S. Jibril, *The Effect of Project-Based Learning Approach on Students' Academic Achievement: A Mixed Meta-Method,***Educational Academic Research,** 52, 2024, 176–187. Available online: https://doi.org/10.33418/education.1421193.

7. L. A. O. Martha, M. I. Anthony & N. G. Jotham, *Influence of Subject Area and Level of Academic Achievement on University Students' Propensity for Academic Dishonesty,* **Journal of Education and Practice,** 13, No.21, 2022, 56-63. Available online: DOI: 10.7176/JEP/13-21-07

8. C. P. Ezurike& A. A. Feyisetan, *Influence of Teacher-Centered and Student-Centered Teaching Methods on the Academic Achievement of Post-Basic Students in Biology in Delta State, Nigeria,***Teacher Education and Curriculum Studies**, 5(3), 2020, 120.Available online: https://doi.org/10.11648/j.tecs.20200503.21.

9. C. Jorge, *National Achievement Test (NAT) Results and Academic achievement: A Comparative Analysis of Filipino Proficiency across Two Academic Years,***EPH - International Journal of Humanities and Social Science,** 9(2), 2024, 14–25. Available online: https://doi.org/10.53555/eijhss.v9i2.193.

10. B. Demir, *The Mediating Effect of Academic Resilience on the Relationship Between Psychological Resilience and Academic Achievement,***E-International Journal of Educational Research,** 14(3),2023,52 - 67.Available online: https://doi.org/10.19160/e-ijer.1253101.

11. F. Francisco*, Is it Beneficial to Stress Grades to my Child? – Relationships between Parental Attitudes towards Academic Achievement, Motivation, Academic Self-Concept and Academic Achievement in Adolescents,***International Journal about Parents in Education**, 5(2), 2023, 98 - 109. Available online: https://doi.org/10.54195/ijpe.18184.

12. B.Mahjabeen, M. I.Yousuf, T.Ehsan& M.Hanif, *Observation of Socio-Emotional Development among Students in Early Childhood Education,* **Qlantic Journal of Social Sciences**, 5(2), 2024, 1-12.

13. G. Joanna & D. Bergh, *Adolescent Academic, Social and Future Achievement Goal Orientations: Implications for Achievement by Gender and Parental Education*, **Scandinavian Journal of Educational Research,** 65(5), 2020, 831–850. Available online: https://doi.org/10.1080/00313831.2020.1755360.

14. K. Thitipat& S. Phusee-orn, *Developing Academic Achievement in Mathematics on Fractions through Active Learning Combined with Skill Practice for Grade 3 Elementary Students,***Higher Education Studies**, 14(2), 2024, 109. Available online: https://doi.org/10.5539/hes.v14n2p109.

15. K. K. Lawler, K. Lori & L. G. Shannon, *Generational differences among associate-degree health students: Retention, academic achievement, and learning perceptions,***International Journal of Advanced Academic Studies,** 3(3), 2021, 192–200. Available online: https://doi.org/10.33545/27068919.2021.v3.i3c.600.

16. J. Buhl-Wiggers, J. Sam & R. Thornton, *Boys Lagging Behind: Unpacking Gender Differences in Academic Achievement across East Africa,***International Journal of Educational Development**, 83, 2021, 102382. Available online: https://doi.org/10.1016/j.ijedudev.2021.102382.

17. H. Cathy, S. Schelfhout, N. Dirix, L. Fonteyne, A. Szmalec& W. Duyck, *Interactions of Gender with Predictors of Academic Achievement,***Contemporary Educational Psychology**, 74, 2023, 102-186.Available online: https://doi.org/10.1016/j.cedpsych.2023.102186.

18. A. D. Adomaitis, S. Diana, K. K. Johnson, R. Sahanoor& A. Attique, *Relationships between dress and gender identity: LGBTQIA+,* **Clothing and Textiles Research Journal**, 42(1), 2024, 3-18. Available online: https://doi.org/10.1177/0887302X211059103

19. A. Bullough, U. Guelich, T. S. Manolova& L. Schjoedt, *Women's entrepreneurship and culture: gender role expectations and identities, societal culture, and the entrepreneurial environment*,**Small Business Economics,** 58(2),2022, 985–996. Available online: https://doi.org/10.1007/s11187-020-00429-6

20. M. B. Phillip, *The Role of Gender Stereotypes and Societal Pressures in Creating Impostor Syndrome in Black Female Entrepreneurs,* **Doctoral Dissertations and Projects,**2024, 5600.Available online: https://digitalcommons.liberty.edu/doctoral/5600

21. K. H. Collins, E. F. Price, L. Hanson &D. Neaves, *Consequences of stereotype threat and imposter syndrome: The personal journey from stem-practitioner to stem-educator for four women of color,***Taboo: The Journal of Culture and Education,** 19(4),2020, 10.Available online: https://digitalscholarship.unlv.edu/taboo/vol19/iss4/10

22. N. Tabassum& B. S. Nayak, *Gender stereotypes and their impact on women's career progressions from a managerial perspective,***IIM Kozhikode Society & Management Review**, 10(2), 2021, 192–208. Available online: https://doi.org/10.1177/2277975220975513

23. N. Conley& D. Bilimoria, *Barriers and mitigating strategies of entrepreneurial business growth: The role of entrepreneur race and gender*,**Entrepreneurship Research Journal**, 12(3), 2021, 391–439.Available online: https://doi.org/10.1515/erj-2020-0061

24. G. Bente, E. Novotny, D. Roth & A. Al-Issa, *Beyond stereotypes: Analyzing gender and cultural differences in nonverbal rapport,***Frontiers in Psychology,** 11, 2020, 599703. Available online: https://doi.org/10.3389/fpsyg.2020.599703

25. O. A. Okpokwasili, *Feminist Ethics: A Framework for Gender Justice.* **Nnadiebube Journal of Gender Studies,** *1*(1). 2024, 15 – 26.

26. L.Cerbara, G.Ciancimino& A. Tintori, *Are we still a sexist society? Primary socialization and adherence to gender roles in childhood,***International Journal of Environmental Research and Public Health,** 19(6),2022, 3408.Available online: https://doi.org/10.3390/ijerph19063408

27. F. Y. Ling, Z. Zhang& S. Y. Tay, *Imposter syndrome and gender stereotypes: Female facility managers' work outcomes and job situations,***Journal of Management in**

Engineering, 36(5),2020, 04020061.Available online: https://doi.org/10.1061/(ASCE)ME.1943-5479.0000831

28. B. Ivanov, *Intersectionality of Gender, Race, Class, Sexuality, Disability and Other Social Identities in Shaping the Experiences and Opportunities of Marginalized Groups in Ukraine,* **International Journal of Gender Studies,** 9(1), 2024, 61 – 74. Available online: https://doi.org/10.47604/ijgs.2357

29. R. Nguyen, *TheIntersectionality of Race, Gender, and Class: Exploring Multiple Dimensions of Inequality.* **Research Consortium Archive,** *2*(01), 2024, 24-30.

30. J. Strübel& G. Saheli, *Clothing and Self-Concept in Cisgender and Transgender Individuals*, **Gender Issues,** 39(4), 2022, 387-408.

31. P. J. Henry& R. L. Steiger, *Sexual orientation as gendered to the everyday perceiver,***Sex Roles,** 87(3-4), 2022, 117–138.Available online: https://doi.org/10.1007/s11199-022-01313-1

32. J. A. Strawser, D. M.Hechavarría& K. Passerini, *Gender and Entrepreneurship: Research Frameworks, Barriers and Opportunities for Women Entrepreneurship Worldwide,***Journal of Small Business Management,** 59(1),2021, 1–15.Available online: https://doi.org/10.1080/00472778.2021.1965615

33. J. Giota& B. Daniel, *Adolescent Academic, Social and Future Achievement Goal Orientations: Implications for Achievement by Gender and Parental Education,***Scandinavian Journal of Educational Research**, 65(5), 2020, 831–850. Available online: https://doi.org/10.1080/00313831.2020.1755360.

34. A. Sandybayev, A. S. J. A. Mohamed & S. A. A. A. Ahmadi, *Digital Education: Intensifying Emirati Student's Performance in the Long Run through Hologram Technology,***Journal of Advances in Humanities and Social Sciences,** 6(4), 2020, 138-146. Available online: doi:https://doi.org/10.20474/jahss-6.4.3

35. M. A. R. Tawalbeh, *Quality of Blended Learning as Perceived by Arab Open University Students,***Journal of Education and Learning (EduLearn),** 14(3), 2020, 449–455.

36. K. K. D. S. Oliveira & R. A. C. de Souza, *Digital Transformation towards Education 4.0,***Informatics in Education,** 21(2), 2022, 283–309. Available online: https://doi.org/10.15388/infedu.2022.13

37. C. B. Mpungose, & S. B. Khoza, *Postgraduate Students' Experiences on the Use of Moodle and Canvas Learning Management System,***Technology, Knowledge and Learning,** 2020, Available online: https://doi.org/10.1007/s10758-020-09475-1

38. M. H. Vo, C. Zhu & A. N. Diep, *Students' Performance in Blended Learning: Disciplinary Difference and Instructional Design Factors,***Journal of Computers in Education,** 7(4), 2020, 487–510. Available online: https://doi.org/10.1007/s40692-020-00164-7

39. J. Iqbal, M. Z. Asghar, M. A. Ashraf & X. T. Yi, *The Impacts of Emotional Intelligence on Students' Study Habits in Blended Learning Environments: The Mediating Role of Cognitive Engagement during Covid-19,***Behavioral Sciences,** 12(1), 2022, 1-19. Available online: doi:https://doi.org/10.3390/bs12010014

40. M. Jazayeri& X. Li, *Examining the Effect of Blended Instructional Method on Students' Grades in an Introductory Statistics Course*, **International Journal of Mathematical Education in Science and Technology,** 2020, 1–10. Available online: https://doi.org/10.1080/0020739X.2020.1775319

41. U. Ramadhani& A. Syazali, *The Effect of Flipped-Problem Based Learning Model Integrated with LMS-Google Classroom For Senior High School Students,***Journal for the Education of Gifted Young Scientists,** 7(2), 2019, 137-158.

42. B. Bervell& I. N. Umar, *Blended Learning or Face-to-Face? Does Tutor Anxiety prevent the Adoption of Learning Management Systems for Distance Education in Ghana?,***Open Learning: The Journal of Open, Distance and e-Learning,** 2018, 1–19. Available online: https://doi.org/10.1080/02680513.2018.1548964

43. A. Adams & A. Dove, *Calculus Students Flipped Out: The Impact of Flipped Learning on Calculus Students' Achievement and Perceptions of Learning*, **PRIMUS,** 28(6), 2017, 600–615. Available online: https://doi.org/10.1080/10511970.2017.1332701

44. M. Almasseri& M. I. Alhojailan, *How Flipped Learning Based on the Cognitive Theory of Multimedia Learning Affects Students' Academic Achievements,***Journal of Computer Assisted Learning,** 2019. Available online: https://doi.org/10.1111/jcal.12386

45. B.C.E. Oguguo, A.O Ocheniand& F.K. Adebayo, *Students' Achievement in Online Test and Measurement Course in Synchronous and Asynchronous E-Learning Platform.***European Journal of Open Education and E-learning Studies,** 6(2), 2021, 137-151. Available Online: https://doi.org/10.46827/ejoe.v6i2.3966

46. N. I. Arshad, M. N. Abdullah, T. N. Z. Tgmalimbusu, M. M. Addi, N. I. Mokhtar, K. S. Kalid& S. K. Sugathan, *Flipping the Classroom to Improve Academic Achievement of Information Systems Students with the Support of Learning Management System (LMS),***ASEAN Journal of Engineering Education**, 4(2), 2020, 8-14.

47. I. Ramlee, A.Marinah, Y. P. Seow& B. A. M. Ridhuan, *Active learning in economic subject: A case study at secondary school,***International Journal of Learning, Teaching and Educational Research,** 19(10), 2020, 19-31. Available online: https://doi.org/10.26803/ijlter.19.10.2

48. Y. Zhao, A. M. P. Llorente& M. C. S. Gómez, *Digital Competence in Higher Education Research: A Systematic Literature Review,***Computers and Education,** 168, 2021, 1-14. Available online: doi:https://doi.org/10.1016/j.compedu.2021.104212

49. Z. Osman, L. Mohamad& R. K. Mohamad, *Enhancing Students' Online Engagement among Online Distance Learning Institutions' Students in Malaysia. The Role of Digital Readiness as a Mediator,***Turkish Online Journal of Qualitative Inquiry,** 12, 2021, 9473-9483.

50. N. A. Mozahem, *Using Learning Management System Activity Data to Predict Student Performance in Face-To-Face Courses*, **International Journal of Mobile and Blended Learning,** 12(3), 2020, 20–31. Available online: https://doi.org/10.4018/IJMBL.2020070102

51. A. I. Fernandez, A. Al Radaideh, G. S. Sisodia, A. Mathew & J. A. Jimber del Río, *Managing University E-Learning Environments and Academic Achievement in the United Arab Emirates: An Instructor and Student Perspective,***PloS One,** 17(5), 2022, 1-16. Available online: doi:https://doi.org/10.1371/journal.pone.0268338

52. O. Palavan, *The Effect of Critical Thinking Education on the Critical Thinking Skills and the Critical Thinking Disposition of Preservice Teachers*, **Educational Research and Reviews,** 15(10), 2020, 606 – 627.

53. N. B. Hamutoglu, E. N. Ü. Bilgiç, H. C. Salar& Y. L. Sahin, *The Effect of E-Learning Experience on Readiness, Attitude, and Self-Control/Self-Management*, **Journal of Information Technology Education: Innovations in Practice,** 20, 2021, 093-120. Available online: doi:https://doi.org/10.28945/4822

54. P. Thapa, S. L. Bhandari & S. Pathak, *Nursing Students' Attitude on the Practice of E-Learning: A Cross-Sectional Survey amid Covid-19 in Nepal.***PloS One**, 16(6), 2021, 1-17.

55. N. Um, *Learners' Attitude toward E-Learning: The Effects of Perceived System Quality and E-Learning Usefulness, Self-Management of Learning, and Self-Efficacy,***International Journal of Contents,** 17(2), 2021, 41-47.

56. E. Chung, G. Subramaniam& L. C. Dass, *Online Learning Readiness among University Students in Malaysia amidst Covid-19,***Asian Journal of University Education,** 16(2), 2020, 45– 58. Available online: https://doi.org/10.24191/AJUE.V16I2.10294

57. N. S. Ismail, N. M. Abu Bakar& S. S. T. S. W. W. Wafa, *Online Learning Challenges During Pandemic Covid-19 in Malaysian Higher Learning Institution,***Universal Journal of Educational Research,** 8(12), 2020, 7151 - 7159. Available online: https://doi.org/10.13189/ujer.2020.081282

58. A. J. Dontre, *The Influence of Technology on Academic Distraction: A Review,***Human Behavior and Emerging Technologies,** 3(3), 2020, 379–390. Available online: https://doi.org/10.1002/hbe2.229

59. A. A. Motz, J. D. Quick, J. A. Wernert& T. A. Miles, *A Pandemic Of Busywork: Increased Online Coursework following the Transition to Remote Instruction is Associated with reduced Academic Achievement,***Online Learning,** 25(1), 2021, 70-85. Available online: https://doi.org/10.24059/olj.v25i1.2475

60. T. H. Huang, F. Liu, L. C. Chen & C. C Tsai, *The Acceptance and Impact of Google Classroom Integrating into a Clinical Pathology Course for Nursing Students: A Technology Acceptance Model Approach,***PloS One,** 16(3), 2021, Available online: https://doi.org/10.1371/journal.pone.024781

61. R. Arumugam, K.K.S. Paramjit, R. Mohan & N.I. Siti, *Blended Learning via Google Classroom: English Language Students Experience Based on Utaut Model and Flow Theory,***Journal of the Hamdard National Foundation, Pakistan,** 43(1), 2020, 172-184.

62. E. Ekpo-Eloma, A. Effiong, A. Bisong& V. Udoh, *Effect of Google Classroom Application on Undergraduate Students' Scores in Educational Technology in University of Calabar, Nigeria,* **Journal of Education and Practice***,* 6(3), 2022, 1 – 12.

63. S. A. Andel, T. de Vreede, P. E. Spector, B. Padmanabhan, V. K. Singh & G. J. de Vreede, *Do Social Features help in Video-Centric Online Learning Platforms? A Presence Perspective,***Computers in Human Behavior,** 2020. Available online: https://doi.org/10.1016/j.chb.2020.106505

64. T. Davis & T. V. Frederick, *The Impact of Multimedia in Course Design on Students' Performance and Online Learning Experience: A Pilot Study of an Introductory Educational Computing Course,***Online Learning,** 24(3), 2020, 147-162. Available online: https://doi.org/10.24059/olj.v24i3.2069

65. F. Fauzan, *The Effectiveness of Google Classroom Media on the Students' Learning Outcomes of Madrasah Ibtidaiyah Teacher Education Department,***JurnalPendidikan Guru MI,** 6(2), 2019, 271-285. Available online: https://doi.org/10.24235/al.ibtida.snj.v6i2.5149

66. N. Khoiriyah& A. Pulungan,*The Effectiveness of Google Classroom in Learning,***LinguistikTerapan**, 19 (1), 2022, 40-44.

67. M. Mehrvarz, E. Heidari, M. Farrokhnia& O. Noroozi, *The Mediating Role of Digital Informal Learning in the Relationship Between Students' Digital Competence and their Academic achievement,***Computers and Education,** 164, 2021, 1-12. Available online: doi:https://doi.org/10.1016/j.compedu.2021.104184

68. A. Haleem, M. Javaid, M. A. Qadri& R. Suman, *Understanding the Role of Digital Technologies in Education: A Review,***Sustainable Operations and Computers**, 3, 2022, 275-285. Available online: https://doi.org/10.1016/j.susoc.2022.05.004

69. S. Tarteer, A. Badah& Z.N. Khlaif, *Employing Google Classroom to Teach Female Students During the Covid-19 Pandemic,***Interdisciplinary Journal of Practice, Theory, and Applied Research,** 2021. Available online: https://doi.org/10.1080/07380569.2021.1988318

70. M. H. Tahir, M. A. H. Adnan, M. S. YaShak, M. D. S. Shah & S. D. Piaralal, *Secondary ESL Teachers use of Google Classroom during COVID-19 pandemic,***Malaysian Journal of Social Sciences and Humanities (MJSSH),** 7(5), 2022, Available online: https://doi.org/10.47405/mjssh.v7i5.1502

71. T. Paterson & M. Prideaux,*Exploring Collaboration in Online Group Based Assessment Contexts: Undergraduate Business Program,***Journal of University Teaching and Learning Practice,** 17(3), 2020.

72. M. H. Hussein, S. H. Ow, I. Ibrahim & M. A. Mahmoud, *Measuring Instructors Continued Intention to reuse Google Classroom in Iraq: A Mixed-Method Study during COVID-19,***Interactive Technology and Smart Education,** 2020. Available online: https://doi.org/10.1108/ITSE06-2020-0095

73. J. Anekwe& U. Amadi, *Effect of Google Classroom on Interest and Performance of Trainee Teachers in Computer Education*, **International Journal of Research and Development,** 5(4), 2020,103-113.

74. R. Mokhtar& M. H. A. Karim, *Exploring Students Behaviour in Using Google Classroom During Covid-19 Pandemic: Unified Theory of Acceptance and Use of Technology (UTAUT).* **Journal of Modern Education,** 3(8), 2021, 182-195.

75. V. Murugesan, & D. Santhirasekaran, *Students' Perception on Using Google Classroom for Learning during Covid-19 Outbreak,* **Asian Journal of English Language and Pedagogy,** 9(1), 2021, 92–101. Available online: https://doi.org/10.37134/ajelp.vol9.1.8.2021

76. A. Widiyatmoko, *The Effectiveness of Google Classroom as a Tool to Support Online Science Learning: A Literature Review,***Journal of Physics: Conference Series,** 2021. Available online: https://doi.org/10.1088/1742-6596/1918/5/052069

77. F. Shakoor, A. Fakhar& J. Abbas, *Impact of Smartphones Usage on the Learning Behaviour and Academic achievement of Students: Empirical Evidence from Pakistan,***International Journal of Academic Research in Business and Social Sciences,** 11(2), 2021, 862– 881. Available online: http://dx.doi.org/10.6007/IJARBSS/v11-i2/8902"

78. S. T. Ahmad, Z. Ramlan& K. S. Krishnan, *Acceptance of Google Classroom for Learning English Exit Test,***International Journal Of Modern Languages And Applied Linguistics,** 4(1), 2020, 67-76. Available online: https://doi.org/10.24191/ijmal.v4i1.9504
79. Senad, *Impact of Google Classroom as an Online Learning Delivery Duringcovid-19 Pandemic: The Case of a Secondary School in Nigeria,***Journal of Education, Society and Behavioural Science,** 33(9), 2021, 53-61.

80. R. Alshammari, *The Current Use of Mobile Devices among Students and Faculty in EFL Teaching in a Saudi Arabian Context,***The Turkish Online Journal of Educational Technology**, 19(2), 2020.

81. F. Ulum, *Student Perception of Using Google Classroom in Mathematics Learning in Covid19 Pandemic*, **International Conference on Information System,** 2020, 27-28. Available online: DOI 10.4108/eai.27-10-2020.2304171

82. S. Karabatak& H. Polat, *The Effects of The Flipped Classroom Model Designed according to the Arcs Motivation Strategies on the Students' Motivation and Academic Achievement Levels,***Education and Information Technologies,** 25(3), 2020, 1475–1495. Available online:https://doi.org/10.1007/s10639-01909985-1

83. L. Da-Hong, L. Hong-Yan, L. Wei, J. Guo& L. En-Zhong, *Application of Flipped Classroom Based on the Rain Classroom in the Teaching of Computer-Aided Landscape Design,***Computer Applications in Engineering Education,** 28(2), 2020, 357–366. Available online: https://doi.org/10.1002/cae.22198

84. H. Aptyka& J. Großschedl, *Analyzing Pre-Service Biology Teachers' Intention to Teach Evolution using the Theory of Planned Behavior*, E**volution,** 15(1), 2022, 16. Available online: https://doi.org/10.1186/s12052-022-00175-1

85. S. S. Jose & E. W. Benjamin, *Factors for Enhancing Achievement in Biology at the Higher Secondary Level,***International Journal of Early Childhood Special Education** (INT-JECSE), 14(5), 2022, 3934-3942.

86. J. Y. Nurul& S. M. Ixora, *Challenges towards the Implementation of ICT In Biology Learning: A Review Study*, **1st International Conference on Chemistry and**

Science Education (IGCSE). Journal of Physics: Conference Series, 1788, 2021, 1-7.

87. W. O. Onu, N. J. Anyaegbunam& A. U. Uzoigwe, *Improving Biology Students' Interest and Achievement through Collaborative Instructional Strategy*, **Journal of Education Society and Behavioral Science,** 33(2), 2020, 9-20.

88. S. O. Ose-Aigbekaen, *A Survey of Teachers' Knowledge and Characteristics of the New Senior Secondary School Biology Curriculum*, **African Journal of Science, Technology and Mathematics Education (AJSTME)**, 5(1), 2020, 87-93.

89. R. M. Samba, B.I. Imoko& I. A. Muluku, *Fostering Senior Secondary Students' Attitude and Achievement in Biology in FCT Abuja using Facebook Instructional Strategy*, **British Journal of Education,** 8(3), 2020, 148-160.
90. R. H. Ristanto, M. Miarsyah, I. A. Luthfi, E. Kristiani& R. Hasanah, *Invertebrate-Interactive Dichotomous Key Media: Enhance Students Learning Motivation in Lower Secondary School,***International Journal of Information and Education Technology,** 10(9), 2020, 669–673. Available online: https://doi.org/10.18178/ijiet.2020.10.9.1441

91. S. Musa & G. Bello, *Effects of Metaphor Instructional Strategy on Senior School Students Achievement in Genetics in Ilorin, Nigeria,***International Journal of Educational Research Review,** 7(3), 2022, 165–175. Available online: https://doi.org/10.24331/ ijere.1098303

92. T. Choden& S. Kijkuakul,*Blending Problem Based Learning with Scientific Argumentation to Enhance Students' Understanding of Basic Genetics*, **International Journal of Instruction**, 13(1), 2020, 445–462. Available online: https://doi.org/10. 29333/iji.2020.13129a

93. F. U. Onowugbeda, *Variation and Genetics as Difficult Topics for Secondary School Students in Biology: Exploring the Impact of Indigenous (Cultural) Knowledge for Better Understanding*, **Breaking Barriers to Learning of Science: The CTC Approach,** 2020, 140–154.

94. R. H. Ristanto, S. Rahayu& S. Mutmainah, *Conceptual Understanding of Excretory System: Implementing Cooperative Integrated Reading and Composition Based on Scientific Approach*, **Participatory Educational Research,** 8(1), 2021, 28–47. Available online: https://doi.org/10.17275/per.21.2.8.1

95. R. H. Ristanto& E. Darmawan, *BiologyReading Literacy: Measurement and Empowerment through Circ Learning Model*, **Journal for the Education of Gifted Young Scientists,** 8(4), 2020, 1305–1318. Available online:https://doi.org/10.17478/JEGYS.679378

96. R. H. Ristanto, R. Djamahar, E. Heryanti& I. Z. Ichsan, *Enhancing Students ' Biology-Critical Thinking Skill through CIRC-Based Scientific Approach (CIRSA).***Universal Journal of Educational Research,** 8(4A), 2020, 1–8. Available online:https://doi.org/10.13189/ujer.2020.081801

97. R. H. Ristanto& R. D. Mahardika, *Digital Flipbook Immunopedia (DFI): A Learning Media to Improve Conceptual of Immune System,***Journal of Physics: Conference Series,** 1796(1), 2021, 012-066. Available online: https://doi.org/10.1088/1742-6596/1796/1/012066

98. R. H. Ristanto, R. Rusdi, R. D. Mahardika, E. Darmawan& N. Ismirawati, *Digital Flipbook Imunopedia (DFI): A Development in Immune System E-Learning Media,***International Journal of Interactive Mobile Technologies (IJIM),** 14(19), 2020, 140. Available online:https://doi.org/10.3991/ijim.v14i19.16795

99. F. H. Permana, E. Sukma& P. Wahyono, *The Use of Distance Learning Through Whatsapp and Google Meeting to Identify Differences in Biology Learning Outcomes*, **Biosfer: PendidikanBiologi,** 14(1), 2021, 86–98. Available online:https://doi.org/10.21009/biosferjpb.20094

100. E. Kristiani, R. H. Ristanto& E. Lisanti, *Exploring Gender-Based Biological Concepts: An Analysis of Bilingual Secondary School Students,* **Biosfer : JurnalPendidikanBiologi**, 13(1), 2020, 1–13.Available online: https://doi.org/10.21009/biosferjpb.v13n1.1-13

101. H. Alabi& I. O. Abimbola, *Score Level, Text Structures and Senior Secondary School Students' Achievement in Genetics in Ilorin*, *Nigeria,* **International Journal of Educational Research Review,** 7(4), 2022, 198–209.

102. O. A. Ajayi& O. P. *Adelana, Effectiveness of Multimedia Self-Learning Package in Teaching and Learning of Genetics in Secondary Schools*. **Journal of Psychometry and Assessment Techniques**, 1(1), 2020, 119–120.

103. O. P. Adelana, A. M. Ishola, & O. Adeeko, *Development and Validation of Instructional Package for Teaching and Learning of Genetics in Secondary Schools,***Asian Journal of Assessment in Teaching and Learning,** 11(2), 2021, 32–41.

104. R. Bernardo, *Reinventing Quantitative Genetics for Plant Breeding: Something Old, Something Who, Something Borrowed Something Blue*, **Heredity,** 125 (6), 2020, 375-385.

105. F. Ahmad, S. Muhammad, K. Evi, C. A. Widi& L. Nurita, *Factor and Rasch Analysis on COVID-19 Genetics Literacy Assessment Instrument,***Eurasia Journal of Mathematics Science and Technology Education,** 17(11), 2021, 1-15.

106. N. Mujahidah& Y. Yusdiana, *Application of Albert Bandura's Social-Cognitive Theories in Teaching and Learning*, **EdukasiIslami: JurnalPendidikan Islam,** *12*(02), 2023, 2131 – 2146.

107. A. Rumjaun& F. Narod, *Social Learning Theory—Albert Bandura,* **Science education in theory and practice: An introductory guide to learning theory**, 2020, 85-99.

108. N. Abdullah, S. S. S. Hassan, M. Abdelmagid, & S. N. M. Ali, *Learning from the Perspectives of Albert Bandura and Abdullah NashihUlwan*: *Implications towards the 21st Century Education***, DinamikaIlmu,** *20*(2), 2020, 199-218.

109. Y. He,*The Inspiration of Bandura's Social Learning Theory to Moral Education in Colleges and Universities*, **Advances in Educational Technology and Psychology,** *6*(10), 2022, 22-29.

110. S. Chuang, *The Applications of Constructivist Learning Theory and Social Learning Theory on Adult Continuous Development*, **Performance Improvement,** *60*(3), 2021, 6-14.

111. J. N. Ahn, D. Hu & M. Vega, *"Do as I do, not as I say": Using Social Learning Theory to Unpack the Impact of Role Models on Students' Outcomes in Education,* **Social and Personality Psychology Compass,** 14(2), 2020, e12517.

112. A. Khushk, M. I. Dacholfany, D. Abdurohim& N. Aman, *Social Learning Theory in Clinical Setting: Connectivism, Constructivism, and Role Modeling Approach,* **Health Economics and Management Review**, 3, 2023, 40-50.

113. F. Hamedi, K. P. Fakhri& P. Adelzadeh,*A Psychoanalytic Study of Two Iranian Novels Based on Albert Bandura's Theory of Cognitive-social Learning,* **Iranian Journal of Comparative Education,** 4(4), 2021, 1479-1496.

114. K. Bhati& T. P. Sethy,*Self-efficacy:Theory to Educational Practice,* **The International Journal of Indian Psychology,** *10*(1), 2022, 1123-1128.

115. M. R. Hardiyana& M. Maemonah, *The Effect of the Application of Albert Bandura's Behaviorism Theory on the Motivation and Learning Outcomes.* **JurnalFundadikdas (Fundamental PendidikanDasar),** *6*(2), 2023, 93-110.

116. S. Hadi, H. Setiyatna& A. Sutiyono, *Learning Behavior Theory according to Ivan Pavlov, Thorndike, Skinner and Albert Bandura,* **Novateur Publications,** (1), 2023, 175-184.

117. A. K. Locklear, *Review of Major Learning Theories: A Mind tool for Understanding and Applying Theoretical Concepts.* **J Ment Health SocBehav,** *2*(108), 2020, 1-6.

118. A. Carvalho, S. J. Teixeira, L. Olim, S. D. Campanella& T. Costa, *Pedagogical Innovation in Higher Education and Active Learning Methodologies–A Case Study,* **Education+ Training,** *63*(2), 2021, 195-213.

119. S. Arık& M. Yılmaz,*The Effect of Constructivist Learning Approach and Active Learning on Environmental Education: A Meta-Analysis Study,* **International Electronic Journal of Environmental Education,** *10*(1), 2020, 44-84.

120. M. A. Qureshi, A. Khaskheli, J. A. Qureshi, S. A. Raza& S. Q. Yousufi, *Factors Affecting Students' Learning Performance through Collaborative Learning and Engagement,* **Interactive Learning Environments**, 31(4), 2023, 2371-2391.

121. R. Li, A. Lund & A. Nordsteien, *The Link Between Flipped and Active Learning: A Scoping Review,* **Teaching in Higher Education,** *28*(8), 2023, 1993-2027.

122. T. N. Bochkareva, E. M. Akhmetshin, A. O. Zekiy, A. V. Moiseev, M. E. Belomestnova, I. A. Savelyeva& O. S. Aleynikova, *The Analysis of Using Active Learning Technology in Institutions of Secondary Vocational Education,* **International Journal of Instruction,** 13(3), 2020, 371-386.

123. R. Ahshan, *A Framework of Implementing Strategies for Active Student Engagement in Remote/Online Teaching and Learning During the COVID-19 Pandemic,* **Education Sciences,** 11(9), 2021, 483.

124. F. Galatsopoulou, C. Kenterelidou, R. Kotsakis& M. Matsiola, *Examining students' perceptions towards video-based and video-assisted active learning scenarios in journalism and communication courses,* **Education Sciences,** *12*(2), 2022, 74.

125. G. Lu, K. Xie& Q. Liu, *What Influences Student Situational Engagement in Smart Classrooms: Perception of the Learning Environment and Students' Motivation,* **British Journal of Educational Technology,** *53*(6), 2022, 1665-1687.

126. E. G. Rincon-Flores & B. N. Santos-Guevara, *Gamification during Covid-19: Promoting Active Learning and Motivation In Higher Education,* **Australasian Journal of Educational Technology,** *37*(5), 2021, 43-60.

127. E. Lugosi & G. Uribe, *Active Learning Strategies with Positive Effects on Students' Achievements in Undergraduate Mathematics Education,* **International Journal of Mathematical Education in Science and Technology,** *53*(2), 2022, 403-424.

128. N. Thambu, H. J. Prayitno& G. A. N. Zakaria,*Incorporating Active Learning into Moral Education to Develop Multiple Intelligences: A Qualitative Approach,* **Indonesian Journal on Learning and Advanced Education** *(IJOLAE)*, 3(1), 2021, 17-29.

129. S. Chuang,*The Applications of Constructivist Learning Theory and Social Learning Theory on Adult Continuous Development*, **Performance Improvement,** 60(3), 2021, 6-14.

130. T. Hailikari, V. Virtanen, M. Vesalainen& L. Postareff, *Student Perspectives on how Different Elements of Constructive Alignment Support Active Learning*, **Active Learning in Higher Education,** 23(3), 2022, 217-231.

131. A. Armellini, V. T. Antunes& R. Howe, *Student Perspectives on Learning Experiences in a Higher Education Active Blended Learning Context,* **TechTrends,** 65(4), 2021, 433-443.

132. E. A. Ayimbila & D. Akantagriwon, *Effect of Concept Mapping Instructional Strategy Accompanied by Discussion Web on Students' Academic Achievement in the Concept of Genetics,* **Journal of Education and Practice,** 5(3), 2021, 1 – 16.

133. C. Gregory,*Integration of ICT in the Teaching and Learning of Genetics in selected Secondary Schools in Kitwe District, Zambia,* 2019, 1 – 158.

134. W. Raheem, *Gender differences and academic achievement and retention of students in Biology among senior secondary school students in Ekiti State,***Computers & Education,**9(2), 2019, 104-116.

135. O. O. Ogbe, *Students' Demography Variables and Academic Achievement in Biology in Calabar Municipality Local Government Area of Cross River State,* 2024, 1 – 63. Available online: https://ssrn.com/abstract=4733028

136. N. E. Nnodim & A. U. Nwanekezi, *Enhancing Students' Performance in Genetics using 5e Learning Cycle and Webquest in Secondary Schools in Rivers state,***International Journal of Multidisciplinary Education and Research,** 8(2), 2023, 1-5.

137. N. M. Sari, K. Y. Yin & Z. Zakariya, *The Effect of Google Classroom-Assisted Learning on the Academic Achievement of Students,* **International Journal of Academic Research in Business and Social Sciences,** 14(4), 2024, 1 – 16. Available online:http://dx.doi.org/10.6007/IJARBSS/v14-i4/21165

138. V. G. Lalap Jr.,*Students' Academic achievement and their Perception on the use of Google Applications in Social Studies,* **EPRA International Journal of Research and Development (IJRD),** 6(7), 2021, 564 – 571. Available online: https://doi.org/10.36713/epra2016

139. U. A. Udo, *Effect of Google Classroom on Computer Education Students' Academic Achievement in Colleges of Education South- South, Nigeria,***International Journal of Contemporary Africa Research Network (CARN),** 1(1), 2024, 152 – 173.

140. A. Osuafor & G. P. Chinasa, *Effect of Flipped Classroom Instruction via Google Classroom on Secondary School Students' Academic Achievement Chemistry in Onitsha Education Zone,* **UNIJERPS Unizik Journal of Educational Research and Policy Studies,** 15 (3), 2023, 86 – 95. Available online:http://sjifactor.com/passport.php?id=21363

141. R. H. Ristanto, E. Kristiani & E. Lisanti,Flipped Classroom–Digital Game-Based Learning (FC-DGBL): Enhancing Genetics Conceptual Understanding of Students in Bilingual Programme, **Journal of Turkish Science Education,** 19(1), 2022, 332-352. Available online: DOI no: 10.36681/tused.2022.124

142. S. M. Suleiman & I. Akilu, *Effect of Flipped Classroom Instruction and Enhanced Lecture Method on Academic achievement in Genetics among Students with Visual-Auditory-Kinesthetic (VAK) Learning Styles in Gusau, Zamfara State, Nigeria,* **Journal of Science, Technology and Mathematics Pedagogy,** 1(2), 2023, 1 – 20.

Chapter Three

Methodology

This chapter explains the research method for this study; it covers the research design, population of the study, sample and sampling techniques, research instruments, validation of instruments, reliability of the research instrument, method of data collection and method of data analysis.

3.1 Research Design

The research design was a quasi-experimental design with 3×2 factorial matrix using pretest- posttest approach. It focuses on treatment which are of three levels (two experimental groups and one control group); digital learning platforms used as treatment for experimental groups(Flipped-Google with collaboration for Group I and Flipped-Google without collaboration for Group II) and traditional teaching strategy used as Control Group III.Further information regarding the research design can be found in Table 3.1 and 3.2.

Table 3.1: Schematic Representation of the Study

Group	1 (Pretest)	Treatment	2 (Posttest)
I_1	O_1	X_1	O_2
I_2	O_3	X_2	O_4
I_3	O_5	X_3	O_6

Source: *Researcher Fieldwork,* 2024

Where O_1, O_3, O_5 = Pretest Scores

O_2, O_4, O_6 = Posttest Scores

I_1, I_2, = Treatment Groups

X_1 = Treatment 1 (Flipped-Google with collaboration)

X_2 = Treatment 2 (Flipped-Google without collaboration)

C = Control (Traditional Teaching Strategy)

Table 3.2: 3 × 2 Factorial Design

Treatment	**Gender**	
	Male	Female
Flipped-Google with collaboration X_1		
Flipped-Google without collaboration X_2		
Traditional Teaching Strategy X_3		

Source: *Researcher Fieldwork,* 2024

Variables in the study

1. Independent variable includes;(digital learning platforms)

   Treatment 1 (Flipped-Google with collaboration)

   Treatment 2 (Flipped-Google without collaboration)

   Control (Traditional Teaching Strategy)

2. Moderator variable includes: Gender

   Male

   Female

3. Dependent variable includes: Academic Achievement in Genetics.

3.2 Population of the Study

The population of study consisted of 3,655 Students which comprises of 1,705 male students and 1,950 female students from all public SS II classes found in the 12 wards in Ibadan North Local Government Area, Oyo State[1].

3.3 Sample and Sampling Techniques

This study employed multistage sampling procedure that comprises two stages. Stage one involves stratification of 12 wards in Ibadan North Local Government Area into three equal stratum – first stratum consists of four wards with 1,206 student, (595 male and 611 female), second stratum also consists of four wards with 1,201students (580male and 621female) and the third stratum consists of four wards with 1,248students (604male and 644female). Stage two involves the purposive selection of three public secondary schools from each stratum of wards in Ibadan North Local Government Area. From the first stratum of four wards (ward 1 – 4); Anglican Commercial Grammar School, Total Garden was purposively selected from ward 4, from the second stratum of four wards (ward 5 – 8); Cheshire High School, Alaro Sango was purposively selected from ward 8 and from the third stratum of four wards (wards 9 – 12) Methodist Grammar School, Bodija was purposively selected from ward 10. Further information regarding the purposive sampling for selected schools can be found in Table 3.3

Table 3.3: Purposive Sampling for Selected Schools

Stratum	**Wards**	**Random Selected Public Senior Secondary Schools (Ib. North LGA)**
Stratum 1	Ward 4	Anglican Comm. Gramm. School, Total Garden
Stratum 2	Ward 8	Cheshire High School, Alaro Sango
Stratum 3	Ward 10	Methodist Grammar School, Bodija
Total	**3**	**3**

Source: *Researcher Fieldwork,* 2024

The three public senior secondary schools in Ibadan North Local Government Area, Oyo state were selected purposively for this study because most students from the selected schools have access to Smartphone

Intact classes were used as sample size from each of the purposive selected public senior secondary schools for this study through the google Classroom link provided for the students to join. .

3.4 Description of Research Instruments

Two instruments were used for this study to collect data, namely:

1. Genetics in Biology Achievement Test (GBAT)
2. Teaching and Learning Activities Guides (TLAG)

3.4.1 Genetics in Biology Achievement Test (GBAT)

This instrument was used to collect data for this study to assess students' academic achievement in Genetics. The instrument consists of different 30 items source from Senior Secondary Certificate Examination (SSCE) past questions because it is valid and will let them know the likely questions to expect in their forth coming examination. The items were multiple-choice like in form of options which were labeled lettered A – E for the participants to shade one correct answer at a time. The given time frame to answer all the items was one hour (1 hr.)

The Genetics in Biology Achievement Test (GBAT) consisted of two sections (A and B). Section A was meant for the participants' demographic information such as: school name, class, gender, group and test type. Section B was the 30 multiple choice items which consist of Genetics concept.

Table 3.4: Table of Specification for Genetics in Biology Achievement Test (GBAT)

Skills	Number of Items	Total	Percentage %
Knowledge	2,8,9,10,12,14,18,2,25	9	30
Comprehension	1,4,7,11,15,21,22,24,27,28,29,30	12	40
Application	3,13,16,17,26,5	6	20
Analysis	6,19,20	3	10
Total	**30**	**30**	**100**

Source: *Researcher Fieldwork,* 2024

3.4.2 Teaching and Learning Activities Guides (TLAG)

These were the lesson notes that guided the activities taken in the teaching and learning process in the selected schools for the study during fieldwork which consisted of school, subject, class, date, duration, topic, instructional materials, behavioral objectives, presentations (Activity 1, Activity 2…), and conclusion. The following were the activities to be taken in each treatment (lesson note):

Lesson Note I: Genetics in Biology - Flipped-Google Classroom with Collaboration Activities Guide for Experimental Group A were as follows:

Pre-Class Activities (Flipped Learning)

Activity1: Introduction to Genetics

Activity2: Exploration of Genetic Traits

Activity3: Reading Assignment

In-Class Activities (Collaborative Learning)

Activity1: Group Discussions

Activity2: Case Studies

Activity3: Problem-Solving Exercises

Activity4: Interactive Presentations

Activity5: Peer Review and Feedback

Post-Class Activities

Activity1: Reflection and Synthesis

Activity2: Extension Activities

Activity3: Assessment

Further information regarding lesson note I can be found in Appendix II

Lesson Note II: Genetics in Biology - Flipped-Google Classroom without Collaboration Activities Guide for Experimental Group B were as follows:

Pre-Class Activities (Flipped Learning):

Activity1: Introduction to Genetics

Activity2: Exploration of Genetic Traits

Activity3: Reading Assignment

In-Class Activities:

Activity1: Guided Practice

Activity2: Teacher-led Discussion

Activity3: Review Session

Activity4: Application Exercises

Post-Class Activities:

Activity 1: Reflection and Synthesis

Activity2: Extension Activities

Activity3: Assessment

Further information regarding lesson notes II can be found in Appendix III

Lesson Note III: Genetics in Biology - Traditional Teaching Strategy Activities Guide for Control Group C were as follows:

Activity1: Introduction to Genetics

Activity2: Lecture on Mendelian Genetics

Activity3: Discussion on Genetic Variation

Activity4: Hands-on Activity: Punnett Squares

Activity5: Introduction to DNA Structure

Activity6: Case Study: Genetic Disorders

Activity7: Review and Assessment

Further information regarding lesson note III can be found in Appendix IV

3.5 Validity of Genetics in Biology Achievement Test (GBAT)

The supervisor scrutinized the Genetics in Biology Achievement Test (GBAT) for its face and content validity evaluation to validate the test before using it to evaluate participants' academic achievement in Genetics. This involved reviewing the instrument (GBAT) for any necessary corrections.

3.6 Reliability of Genetics in Biology Achievement Test (GBAT)

The instrument's reliability value was determined using Kuder-Richardson (KR-20) by administering the Genetics in Biology Achievement Test (GBAT) to a

different group of participants who attend a different school but have similar attributes with reliability value of 0.79.

3.7 Method of Data Collection

In a quasi-experimental study that uses an achievement test, data collection involves carefully gathering information on participant performances or findings for the particular construct being studied. The researcher obtained a letter of Introduction from the Head of Department requesting permission from the Principals and Biology teachers of the selected schools in order to appropriately administer the achievement test for data collection. Informed consent outlining the goal, methodology, possible advantages, and difficulties of the study was provided to the participants. There was training for teachers or research assistants. A thorough explanation of the study's goals and the steps required to finish it in eight weeks were covered at the training session.

Research assistants were trained on study specific methodologies for instruction during the first week of fieldwork. Pretest was administered on participants in the second week. Implementing the treatment plan based on the assigned teaching strategy for each of the purposive selected schools for the study took place over the course of the next five weeks (week three to seven). In week eight, the posttest was administered.

3.7.1 Data Administration

Biology teachers (Research Assistants) from the study's selected schools received training on how to lead students in experimental group A through the use of

Flipped-Google Classroom with Collaboration Activities Guide, students in experimental group B through the use of Flipped-Google Classroom without Collaboration Activities Guide, and in control group C through the use of Traditional teaching strategy while utilizing the researcher's prepared lesson notes. Following the training, the researcher observed the research assistants or Biology teachers while they continued the experiment under the supervision of the researcher for 30 minutes, testing their knowledge of the material. Both the experimental and control groups' participants were exposed to the same duration of time (periods). Every week for five weeks (week three to week seven), a period was used in each of the schools where the treatments were administered. Before the commencement of the experiment, the participants took the Pre-test, and at the end of experiment, they took the Post-test.

3.8 Method of Data Analysis

The data was analyzed using inferential statistics and the hypotheses that were formulated for the study were tested using Analysis of Covariance (ANCOVA) at 0.05 level of significance.

Endnote

1. Ibadan North LGA Local Inspection of Education (LIE), *Public Secondary Schools SS II Enrolments in the twelve wards of Ibadan North Local Government Area*, Oyo state, 2024

Chapter Four

Results and Discussion of Findings

This chapter shows demographic data analysis, presentations of data, Analysis of Covariance (ANCOVA) results tested at 0.05 level of significant, and discussion of findings.

4.1 Demographic Data Analysis

Table 4.1.0: Treatments and Gender Distribution

Treatments	Gender		Total
	Male	Female	
Flipped google classroom with collaboration	15	15	30
Flipped google classroom without collaboration	16	18	34
Conventional teaching Strategy	19	21	40
Total	**50**	**54**	

Source: *Researcher Fieldwork,* 2024

Table 4.1.0 shows the treatments and the gender distributions

4.2 Testing of Hypotheses

4.2.1

$H_0$1: There will be no significant main effect of Treatment on Senior Secondary School Students' Academic Achievement in Genetics.

Table 4.1.1: Main and interaction effects of treatment and gender on post-achievement in genetics

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	147.589	6	24.598	3.059	0.009	0.161
Intercept	1245.322	1	1245.322	154.866	0.000	0.617
Pre Achievement	0.261	1	0.261	0.032	0.857	0.000
Treatment	122.276	2	61.138	7.603*	0.001	0.137
Gender	6.178	1	6.178	0.768	0.383	0.008
Treatment x Gender	15.674	2	7.837	0.975	0.381	0.020
Error	771.965	96	8.041			
Total	36338.000	103				
Corrected Total	919.553	102				

Source: *Researcher Fieldwork,* 2024
R Squared = 0.16 (Adjusted R Squared = 0.11) * denotes significant at $p<0.05$

Table 4.1.1 revealed a significant main effect of treatment (flipped-google classroom with collaborative learning approach and flipped google classroom without collaborative learning approach) on students' post-achievement in genetics ($F_{(2;\ 101)} = 7.60$; $p<0.05$, partial $\eta^2 = 0.14$) after adjusting for pre-achievement. Table 4.1.1 revealed an effect size of 14.0%, which implies that treatment alone accounted for 14.0% of the variance in student's post-achievement in genetics in post-knowledge in genetics. Thus, the Null hypothesis 1 was rejected. This implies that treatment had effect on students' post-achievement in genetics. The differences in the post-achievement mean scores of the students exposed to different treatment and control condition are established by the estimated marginal mean analysis and the result presented in Table 4.1.2

Table 4.1.2: Mean Performance by Treatment and Control groups

Treatment	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Flipped Google with Collaboration (FGWC)	19.77	0.52	18.7	20.79
Flipped Google without Collaboration (FGWOC)	19.05	0.50	18.06	20.0
Conventional Teaching Strategy (CONTS)	17.21	0.45	16.32	18.11

Source: *Researcher Fieldwork,* 2024

Table 4.1.2 revealed that students exposed to Flipped- Google with collaboration had the highest adjusted post-achievement mean score of 19.77, followed by those in the Flipped- Google without collaboration with mean score of 19.05, while their counterparts exposed to the conventional teaching strategy had the lowest adjusted post-achievement mean score of 17.21. This order is presented as FGWC >FGWOC > CONTS. The Bonferroni post hoc test of multiple comparisons was carried out to determine the source of the significant main effect observed and the result is presented in Table 4.1.2

Table 4.1.3: Bonferroni comparison of Treatment and Control Groups Means by Post-Achievement in Genetics

(I) Treatment	(J) Treatment	Mean Difference(I-J)	Sig.
Flipped Google with Collaboration	Flipped Google without Collaboration	0.721	0.956
	Conventional Teaching Strategy	2.553	0.001*
Flipped Google without Collaboration	Flipped Google with Collaboration	-0.721	.956
	Conventional Teaching Strategy	1.832	0.024*
Conventional Teaching Strategy	Flipped Google with Collaboration	-2.553	0.001*
	Flipped Google without Collaboration	-1.832	0.024

Source: *Researcher Fieldwork,* 2024

* denotes significant $p<0.05$

Table 4.1.3 showed that the difference in the adjusted post-achievement mean score of students between the two treatment groups (flipped-google with collaboration and flipped-google without collaboration) to genetics was not significant. The mean difference between students exposed to flipped google with collaboration and conventional teaching strategy to genetics was statistically significant. Furthermore, Table 4.1.3 indicated that that the difference in the mean score of students in the flipped google without collaboration and conventional teaching strategy to genetics was significant. This indicated that flipped google with collaboration and flipped google without collaboration were the main cause of difference observed as students' post-achievement in genetics concepts is concerned.

Ho2: There is no significant main effect of Gender on students' achievement in genetics

Table 4.1.1 revealed that the main effect of gender on students' achievement in genetics in biology ($F_{(2, 102)} = 0.77$; $p>0.05$) was not significant. It was observed that the p-value of 0.383 was greater than the 0.05 level of significance, indicating that that the null hypothesis 2 was not rejected. This implies that gender had no effect on students' post-achievement in genetics.

Ho3: There is no significant interaction effect of treatment and Gender on students' academic achievement in genetics

The result of the 2-way interaction effect in Table 4.1.1, indicated that there was no significant interaction effect of treatment and gender on students' post-achievement scores in genetics in biology ($F_{(2, 101)} = 0.98$; $p>0.05$). Thus, null hypothesis 3 was not rejected. This means that students' post-achievement score in genetics did not vary significantly among male and female students after the intervention.

4.3 Discussion of Findings

There was a significant main effect of treatment on senior secondary school students' academic achievement in Genetics which is in line with previous study: Students' Academic achievement and their perception on the use of google applications in Social Studies[1]. It was discovered in the previous study that the use of google applications has a significant effect on the academic achievement of the

chosen Grade 7 students in learning Social Studies, as measured by pre- and post-test results. This claim that using google applications has no significant effect on the academic achievement of the chosen seventh-grade students in their social studies classes is not supported which is the same with the current study result but different in subject matter and selected students' level of education. Though, flipped classroom and collaboration learning approach were not performed in the previous study but the previous and current studies used google applications. It is also in line with previous study: effects of flipped classroom instruction via google classroom on Secondary School Students' Academic Achievement Chemistry in Onitsha Education Zone[2]. The previous results revealed that there is a statistically significant difference in the academic achievement of students taught chemistry using the FCIVGC method and those taught using the lecture approach, with the FCIVGC group performing significantly better. In spite the fact that both current and previous studies adopted the same teaching strategy with the same results for the same level of students' education, their subject matters were quite different.

Also in line with previous study: effects of google classroom on Computer Education Students' Academic Achievement in Colleges of Education in the South-South, Nigeria[3]. Findings of the previous study showed that there was a significant difference between the academic achievement scores of students taught an operating system through google classroom and those taught an operating system through traditional classroom which also the same with current study result. From previous study result, students taught using Google Classroom outperformed those taught in Traditional Classroom through the cognitive performance scores of students which

also be the same case in the present study result; despite the fact that both studies were carried out on different levels of education and subject matter, they used the same teaching strategy which result to similar conclusion.

There was no significant main effect of gender on senior secondary school students' academic achievement in Genetics which is in line with previous study: Effect of Concept Mapping Instructional Strategy accompanied by Discussion Web on Students' Academic Achievement in the Concept of Genetics[4]. The current study result shared the same result with the experimental group in the previous study result which showed that there was no statistically significant difference between the academic achievement of male and female students. The present study result is not in line with previous study: Integration of ICT in the teaching and learning of Genetics in selected Secondary Schools in Kitwe District, Zambia[5].The previous study findings indicated a significant difference in the genetic performance of the experimental groups and the control groups according to gender and group names. In addition, the current study result is not in line with previous study: Gender differences and academic achievement and retention of students in Biology among Senior Secondary School Students in Ekiti State[6]. The previous study findings also indicated that there is a significant difference between the achievements means scores of male and female students. Furthermore, the current study result is not in line with previous study: Students' demography variables and academic achievement in Biology in Calabar Municipality Local Government Area of Cross River State[7]. The previous study's conclusion showed that, in the Calabar Municipality Local Government Area of Cross River State, Nigeria, SS 11 Biology students' academic achievement was significantly

influenced by their gender, age, and birth order. The current study result is in line with previous study: Enhancing Students' performance in Genetics using 5e Learning Cycle and Webquest in Secondary Schools in Rivers state[8]. The performance of both male and female students taught genetics from the previous study result, there was no significant interaction effect of the 5E learning cycle and web Quest; though, both studies used different teaching strategies.

There was no significant interaction effect of treatment (flipped-google classroom with collaborative learning approach and flipped google classroom without collaborative learning approach) and gender on senior secondary school students' academic achievement in Genetics which is in line with previous study: The effect of google classroom-assisted learning on the academic achievement of students[9]. The ANCOVA test results from previous study indicate no significant difference in post-student accomplishment in Economics from the selected Malaysia Universities based on learning methodologies [Google Classroom Support with Collaborative Learning Approach (GCDK), Google Classroom Support without Collaborative Learning Approach (GCTK) and Traditional Learning Approach (KPK)]. Although, there exist differences in both studies' geographical scope and level of education; but there also exist similarities in both studies' contextual scope. The current study is not in line with the study;Effect of flipped classroom instruction via google classroom on Secondary School Students' Academic Achievement in Chemistry in Onitsha Education Zone[2]. The previous results revealed that there is a statistically significant difference in the academic attitude achievement of students taught chemistry using the FCIVGC method and those taught using the lecture approach, with the FCIVGC

group performing significantly better. There is significant interaction effect of instructional approach and gender on students' achievement in chemistry. Based on this, FCIVGC favors both male and female chemistry students and is gender unbiased. Overall, the research has demonstrated that Brame's FCIVGC is useful for improving Chemistry achievement. It was determined that FCIVGC promotes a positive attitude in male chemistry students and is more successful in helping them attain academic success. It was suggested that educators use FCIVGC for instructing and learning chemistry which is also recommended in the current study. Though, there exist differences in subject matter, geographical scope and collaboration style involved in using flipped classroom instruction via google classroom to teach.

Endnotes

1. V. G. Lalap Jr., *Students' Academic Achievement And Their Perception On The Use .Of Google Applications in Social Studies,* **EPRA International Journal of Research and Development (IJRD),** 6(7), 2021, 564 – 571. Available online: https://doi.org/10.36713/epra2016

2. A. Osuafor & G. P. Chinasa, *Effect of Flipped Classroom Instruction via Google Classroom on Secondary School Students' Academic Achievement Chemistry in Onitsha Education Zone,* **UNIJERPS Unizik Journal of Educational Research and Policy Studies,** 15 (3), 2023, 86 – 95. Available online:http://sjifactor.com/passport.php?id=21363

3. U. A. Udo, *Effect of Google Classroom on Computer Education Students' Academic Achievement in Colleges of Education South- South, Nigeria,***International Journal of Contemporary Africa Research Network (CARN),** 1(1), 2024, 152 – 173.

4. E. A. Ayimbila & D. Akantagriwon, *Effect of Concept Mapping Instructional Strategy Accompanied by Discussion Web on Students' Academic Achievement in the Concept of Genetics,* **Journal of Education and Practice,** 5(3), 2021, 1 – 16.

5. A. Gregory, *Integration of ICT in the Teaching and Learning of Genetics in selected Secondary Schools in Kitwe District, Zambia,* 2019, 1 – 158.

6. W. Raheem, *Gender Differences And Academic Achievement And Retention Of Students In Biology Among Senior Secondary School Students In Ekiti State,* **Computers & Education,**9(2), 2019, 104-116.

7. O. O. Ogbe, *Students' Demography Variables and Academic Achievement in Biology in Calabar Municipality Local Government Area of Cross River State,* 2024, 1 – 63. Available online: https://ssrn.com/abstract=4733028

8. N. E. Nnodim & A. U. Nwanekezi, *Enhancing Students' Performance In Genetics Using 5e Learning Cycle and Webquest in Secondary Schools in Rivers state,* **International Journal of Multidisciplinary Education and Research,** 8(2), 2023, 1-5.

9. N. M. Sari, K. Y. Yin & Z. Zakariya, *The Effect of Google Classroom-Assisted Learning on the Academic Achievement of Students,* **International Journal of Academic Research in Business and Social Sciences,** 14(4), 2024, 1 – 16. Available online:http://dx.doi.org/10.6007/IJARBSS/v14-i4/21165

Chapter Five

Conclusion

5.1 Summary of Findings

The summary of the research findings, based on the data of the study sampled are presented thus;

There was a significant main effect of treatment (flipped-google classroom with collaborative learning approach (FGWC) and flipped google classroom without collaborative learning approach (FGWOC)) on senior secondary school students' academic achievement in Genetics.[$F_{(2, 101)} = 7.60$; $p < 0.05$].

There was no significant main effect of gender on senior secondary school students' academic achievement in Genetics.[$F_{(2, 102)} = 0.77$; $p > 0.05$].

There was no significant interaction effect of treatment (flipped-google Classroom with collaborative learning approach (FGWC) and flipped google classroom without collaborative learning approach (FGWOC)) and gender on senior secondary school students' academic achievement in Genetics.[$F_{(2, 101)} = 0.98$; $p > 0.05$].

5.2 Conclusion

Based on the findings of this study, the main effect of treatment was found to be significant on student academic achievement in Genetics, while the main Effect of gender and interaction effect of treatment and gender were not significant. It is concluded that both the digital learning (flipped–google classroom with/without collaboration learning) Strategy are effective to teach Genetics concept in Biology irrespective of the students gender

5.3 Recommendations

From the findings of this study, the following recommendations / suggestions are made.

i. Flipped–Google Classroom with collaborative learning approach (FGWC) and Flipped-Google Classroom without collaborative learning approach (FGWOC) should be adopted by Biology Teacher in other to improve Student academic achievement in Genetics.

ii. The strategies are suitable for both male and female students; therefore Biology Teachers should adopt these strategies when gender factor is being considered.

iii. Government and Non- governmental organizations should organize seminars and workshop in other to familiarize teacher with these innovative strategies so as to be used in our schools.

5.4 Suggested Area for Further Research

For further studies, similar study should be done in other geographical zones in the Country using other variables such as students' attitude, school type and other forms of digital learning platforms can be used. It can also be replicated in other school subjects such as Physics, Chemistry and can be carried out in Higher Institutions be it private or public institutions.

Bibliography

Journal

Abdullah N., Hassan S. S. S., Abdelmagid M., & Ali S. N. M., *Learning From The Perspectives of Albert Bandura and Abdullah NashihUlwan*: *Implications Towards The 21st Century Education***, DinamikaIlmu,** *20*(2), 2020, 199-218.

Adams A. & Dove A., *Calculus Students Flipped Out: The Impact of Flipped Learning On Calculus Students' Achievement and Perceptions of Learning*, **PRIMUS,** 28(6), 2017, 600–615. Available online: https://doi.org/10.1080/10511970.2017.1332701

Adelana O. P., Ayanwale M. A. & Sanusi I. T., *Exploring Pre-Service Biology Teachers' Intention To Teach Genetics Using An AI Intelligent Tutoring - Based System*, **Cogent Education**, 11(1), 2024, 1 – 25. Available online: https://doi.org/10.1080/2331186X.2024.2310976

Adelana O. P., Ishola A. M. & Adeeko O., *Development and Validation of Instructional Package for Teaching and Learning of Genetics in Secondary Schools,* **Asian Journal of Assessment in Teaching and Learning,** 11(2), 2021, 32–41.

Adomaitis A. D., Diana S., Johnson K. K., Sahanoor R. & Attique A., *Relationships Between Dress and Gender Identity: LGBTQIA+,* **Clothing and Textiles Research Journal**, 42(1), 2024, 3-18. Available online: https://doi.org/10.1177/0887302X211059103

Ahmad F., Muhammad S., Evi K., Widi C. A. & Nurita L., *Factor And Rasch Analysis On COVID-19 Genetics Literacy Assessment Instrument,* **Eurasia Journal Of Mathematics Science And Technology Education,** 17(11), 2021, 1-15.

Ahmad S. T., Ramlan Z. & Krishnan K. S., *Acceptance of Google Classroom for Learning English Exit Test,* **International Journal Of Modern Languages And Applied Linguistics,** 4(1), 2020, 67-76. Available online: https://doi.org/10.24191/ijmal.v4i1.9504

Ahn J. N., Hu D. & Vega M., *"Do as I do, not as I say": Using Social Learning Theory to Unpack the Impact of Role Models on Students' Outcomes in Education,* **Social And Personality Psychology Compass,** 14(2), 2020, e12517.

Ahshan R., *A Framework of Implementing Strategies For Active Student Engagement In Remote/Online Teaching And Learning During The COVID-19 Pandemic,* **Education Sciences,** 11(9), 2021, 483.

Ajayi O. A. & Adelana O. P., *Effectiveness of Multimedia Self-Learning Package in Teaching and Learning of Genetics in Secondary Schools*. **Journal of Psychometry And Assessment Techniques**, 1(1), 2020, 119–120

Al Arif T. Z., *The Influences of Audio Visual Media And Vocabulary Mastery towards English Learning Achievement of EFL Students*, **J-SHMIC : Journal of English For Academic**, 7(1), 2020, 57–65. Available online: https://doi.org/10.25299/jshmic.2020.vol7(1).3905.

Alabi H. & Abimbola I. O., *Score Level, Text Structures and Senior Secondary School Students' Achievement in Genetics in Ilorin*, *Nigeria,* **International Journal of Educational Research Review,** 7(4), 2022, 198–209.

Alshammari R., *The Current Use of Mobile Devices among Students and Faculty in EFL Teaching in a Saudi Arabian Context,* **The Turkish Online Journal of Educational Technology**, 19(2), 2020.

Almasseri M. & Al Hojailan M. I., *How Flipped Learning Based on the Cognitive Theory of Multimedia Learning Affects Students' Academic Achievements,* **Journal of Computer Assisted Learning,** 2019. Available online: https://doi.org/10.1111/jcal.12386

Amiri E. & El Karfa A., *The Impact of Learning Environment on EFL Students' Academic Achievement: A study of Socio-Cultural Factors Affecting Academic Achievement*, **Arab World English Journal**, 12(4), 2021, 387–400.Available online: https://doi.org/10.24093/awej/vol12no4.25.

Andel S. A., de Vreede T., Spector P. E., Padmanabhan B., Singh V. K. & de Vreede G. J., *Do Social Features help in Video-Centric Online Learning Platforms? A Presence Perspective,* **Computers in Human Behavior,** 2020. Available online: https://doi.org/10.1016/j.chb.2020.106505

Anekwe J. & Amadi U., *Effect of Google Classroom on Interest and Performance of Trainee Teachers in Computer Education*, **International Journal of Research and Development,** 5(4), 2020,103-113.

Aptyka H. & Großschedl J., *Analyzing Pre-Service Biology Teachers' Intention to Teach Evolution using the Theory of Planned Behavior*, **Evolution,** 15(1), 2022, 16. Available online: https://doi.org/10.1186/s12052-022-00175-1

Arık S. & Yılmaz M., *The Effect of Constructivist Learning Approach and Active Learning on Environmental Education: A Meta-Analysis Study,* **International Electronic Journal of Environmental Education,** *10*(1), 2020, 44-84.

Armellini A., Antunes V. T. & Howe R., *Student Perspectives on Learning Experiences in a Higher Education Active Blended Learning Context,* **TechTrends,** 65(4), 2021, 433-443.

Arshad N. I., Abdullah M. N., TgMalimBusu T. N. Z., Addi M. M., Mokhtar N. I., Kalid K. S. & Sugathan S. K., *Flipping the Classroom to Improve Academic Achievement of Information Systems Students with the Support of Learning Management System (LMS),***ASEAN Journal Of Engineering Education**, 4(2), 2020, 8-14.

Arumugam R., Paramjit K.K.S., Mohan R. & Siti N. I., *Blended Learning via Google Classroom: English Language Students Experience Based on Utaut Model and Flow Theory,* **Journal of the Hamdard National Foundation, Pakistan,** 43(1), 2020, 172-184.

Ayimbila E. A. & Akantagriwon D., *Effect of Concept Mapping Instructional Strategy Accompanied by Discussion Web on Students' Academic Achievement in the Concept of Genetics,* **Journal of Education and Practice,** 5(3), 2021, 1 – 16.

Bente G., Novotny E., Roth D. & Al-Issa A., *Beyond Stereotypes: Analyzing Gender and Cultural Differences in Nonverbal Rapport,* **Frontiers in Psychology,** 11, 2020, 599703. Available online: https://doi.org/10.3389/fpsyg.2020.599703

Bernardo R., *Reinventing Quantitative Genetics for Plant Breeding: Something Old, Something Who, Something Borrowed Something Blue*, **Heredity,** 125 (6), 2020, 375-385.

Bervell B. & Umar I. N., *Blended Learning or Face-to-Face? Does Tutor Anxiety prevent the Adoption of Learning Management Systems for Distance Education in Ghana?,* **Open Learning: The Journal of Open, Distance and e-Learning,** 2018, 1–19. Available online: https://doi.org/10.1080/02680513.2018.1548964

Bhati K. & Sethy T. P., *Self-efficacy: Theory to Educational Practice,* **The International Journal of Indian Psychology,** *10*(1), 2022, 1123-1128.

Bochkareva T. N., Akhmetshin E. M., Zekiy A. O., Moiseev A. V., Belomestnova M. E., Savelyeva I. A. & Aleynikova O. S., *The Analysis of Using Active Learning Technology in Institutions of Secondary Vocational Education,* **International Journal of Instruction,** 13(3), 2020, 371-386.

Buhl-Wiggers J., Sam J. & Thornton R., *Boys Lagging Behind: Unpacking Gender Differences in Academic Achievement across East Africa,* **International Journal of Educational Development**, 83, 2021, 102382. Available online: https://doi.org/10.1016/j.ijedudev.2021.102382.

Bullough A., Guelich U., Manolova T. S. & Schjoedt L., *Women's Entrepreneurship and Culture: Gender Role Expectations and Identities, Societal Culture, and The Entrepreneurial Environment*, **Small Business Economics,** 58(2),2022, 985–996. Available online: https://doi.org/10.1007/s11187-020-00429-6

Carvalho A., Teixeira S. J., Olim L., Campanella S. D. & Costa T., *Pedagogical Innovation in Higher Education and Active Learning Methodologies–A Case Study,* **Education+ Training,** *63*(2), 2021, 195-213.

Cathy H., Schelfhout S., Dirix N., Fonteyne L., Szmalec A. & Duyck W., *Interactions of Gender with Predictors of Academic Achievement,* **Contemporary Educational Psychology**, 74, 2023, 102-186.Available online: https://doi.org/10.1016/j.cedpsych.2023.102186.

Cerbara L., Ciancimino G. & Tintori A., *Are we Still A Sexist Society? Primary Socialization And Adherence To Gender Roles In Childhood,* **International Journal of Environmental Research and Public Health,** 19(6),2022, 3408.Available online: https://doi.org/10.3390/ijerph19063408

Choden T. & Kijkuakul S., *Blending Problem Based Learning with Scientific Argumentation to Enhance Students' Understanding Of Basic Genetics*, **International Journal of Instruction**, 13(1), 2020, 445–462. Available online: https://doi.org/10. 29333/iji.2020.13129a

Chuang S., *The Applications of Constructivist Learning Theory and Social Learning Theory on Adult Continuous Development*, **Performance Improvement,** *60*(3), 2021, 6-14.

Chung E., Subramaniam G. & Dass L. C., *Online Learning Readiness Among University Students in Malaysia amidst Covid-19,***Asian Journal of University Education,** 16(2), 2020, 45– 58. Available online: https://doi.org/10.24191/AJUE.V16I2.10294

Collins K. H., Price E. F., Hanson L. & Neaves D., *Consequences of Stereotype Threat And Imposter Syndrome: The Personal Journey From Stem-Practitioner To Stem-Educator for Four Women of Color,* **Taboo: The Journal of Culture and Education,** 19(4), 2020, 10. Available online: https://digitalscholarship.unlv.edu/taboo/vol19/iss4/10

Conley N. & Bilimoria D., *Barriers and Mitigating Strategies of Entrepreneurial Business Growth: The Role of Entrepreneur Race and Gender*, **Entrepreneurship Research Journal**, 12(3), 2021, 391–439.Available online: https://doi.org/10.1515/erj-2020-0061

Da-Hong L., Hong-Yan L., Wei L., Guo J. & En-Zhong L., *Application of Flipped Classroom Based On The Rain Classroom In The Teaching Of Computer-Aided Landscape Design,* **Computer Applications in Engineering Education,** 28(2), 2020, 357–366. Available online: https://doi.org/10.1002/cae.22198

Davis T. & Frederick T. V., *The Impact of Multimedia in Course Design on Students' Performance and Online Learning Experience: A Pilot Study Of An Introductory Educational Computing Course,* **Online Learning,** 24(3), 2020, 147-162. Available online: https://doi.org/10.24059/olj.v24i3.2069

Demir B., *The Mediating Effect of Academic Resilience on the Relationship Between Psychological Resilience and Academic Achievement,* **E-International Journal of Educational Research,** 14(3),2023,52 - 67.Available online: https://doi.org/10.19160/e-ijer.1253101.

Dominik S., & Weil T., *Chemical Reactions in Living Systems,* **Advanced Science**, 11(8), 2023, Available online: https://doi.org/10.1002/advs.202303396.

Dontre A. J., *The Influence of Technology on Academic Distraction: A Review,* **Human Behavior and Emerging Technologies,** 3(3), 2020, 379–390. Available online: https://doi.org/10.1002/hbe2.229

Ekpo-Eloma E., Effiong A., Bisong A. & Udoh V., *Effect of Google Classroom Application on Undergraduate Students' Scores in Educational Technology in University of Calabar, Nigeria,* **Journal of Education and Practice**, 6(3), 2022, 1 – 12.

Ezurike C. P. & Feyisetan A. A., *Influence of Teacher-Centered and Student-Centered Teaching Methods on the Academic Achievement of Post-Basic Students in Biology in Delta State, Nigeria,* **Teacher Education and Curriculum Studies**, 5(3), 2020, 120.Available online: https://doi.org/10.11648/j.tecs.20200503.21.

Faiza A., *Digital Learning Attributes and Students' Academic Achievement among Pakistani Entrepreneurship Students: Mediating role of student engagement,* **Journal of Advanced Research in Social Sciences and Humanities**, 7(3), 2022,95-107. Available online: https://doi.org/10.26500/jarssh-07-2022-0301.

Fernandez A. I., Al Radaideh A., Sisodia G. S., Mathew A. & Jimber del Río J. A., *Managing University E-Learning Environments and Academic Achievement in the United Arab Emirates: An Instructor and Student Perspective,* **PloS One,** 17(5), 2022, 1-16. Available online: doi:https://doi.org/10.1371/journal.pone.0268338

Francisco F., *Is it Beneficial to Stress Grades To My Child? – Relationships Between Parental Attitudes towards Academic Achievement, Motivation, Academic Self-Concept and Academic Achievement in Adolescents,* **International Journal about Parents in Education**, 5(2), 2023, 98 - 109. Available online: https://doi.org/10.54195/ijpe.18184.

Galatsopoulou F., Kenterelidou C., Kotsakis R. & Matsiola M., *Examining Students' Perceptions towards Video-Based and Video-Assisted Active Learning*

*Scenarios in Journalism and Communication Courses,***Education Sciences,** *12*(2), 2022, 74.

Giota J. & Daniel B., *Adolescent Academic, Social and Future Achievement Goal Orientations: Implications for Achievement by Gender and Parental Education,* **Scandinavian Journal of Educational Research**, 65(5), 2020, 831–850. Available online: https://doi.org/10.1080/00313831.2020.1755360.

Gregory C., *Integration of ICT In The Teaching And Learning Of Genetics In Selected Secondary Schools In Kitwe District, Zambia,* 2019, 1 – 158.

Hadi S., Setiyatna H. & Sutiyono A., *Learning Behavior Theory according to Ivan Pavlov, Thorndike, Skinner and Albert Bandura,* **Novateur Publications,** (1), 2023, 175-184.

Hailikari T., Virtanen V., Vesalainen M. & Postareff L., *Student Perspectives on how Different Elements of Constructive Alignment Support Active Learning*, **Active Learning in Higher Education,** 23(3), 2022, 217-231.

Haleem A., Javaid M., Qadri M. A. & Suman R., *Understanding the Role of Digital Technologies in Education: A Review,* **Sustainable Operations and Computers**, 3, 2022, 275-285. Available online: https://doi.org/10.1016/j.susoc.2022.05.004

Hamedi F., Fakhri K. P. & Adelzadeh P., *A Psychoanalytic Study of Two Iranian Novels Based on Albert Bandura's Theory of Cognitive-social Learning,* **Iranian Journal of Comparative Education,** 4(4), 2021, 1479-1496.

Hamutoglu N. B., Bilgiç E. N. Ü., Salar H. C. & Sahin Y. L., *The Effect of E-Learning Experience on Readiness, Attitude, and Self-Control/Self-Management*, **Journal of Information Technology Education: Innovations in Practice,** 20, 2021, 093-120. Available online: doi:https://doi.org/10.28945/4822

Hardiyana M. R. & Maemonah M., *The Effect of the Application of Albert Bandura's Behaviorism Theory on the Motivation and Learning Outcomes.* **Jurnal Fundadikdas (Fundamental Pendidikan Dasar),** *6*(2), 2023, 93-110.

Hauspie C., Stijn S., Nicolas D., Lot F., Arnaud S. & Wouter D., *Interactions of Gender with Predictors of Academic Achievement,* **Contemporary Educational Psychology**, 74, 2023, 102-186. Available online: https://doi.org/10.1016/j.cedpsych.2023.102186.

He Y., *The Inspiration of Bandura's Social Learning Theory to Moral Education in Colleges and Universities*, **Advances in Educational Technology and Psychology,** *6*(10), 2022, 22-29.

Henry P. J. & Steiger R. L., *Sexual orientation as gendered to the everyday perceiver,***Sex Roles,** 87(3-4), 2022, 117–138.Available online: https://doi.org/10.1007/s11199-022-01313-1

Huang T. H., Liu F., Chen L. C. & Tsai C. C., *The Acceptance and Impact of Google Classroom Integrating into a Clinical Pathology Course for Nursing Students: A Technology Acceptance Model Approach,* **PloS One,** 16(3), 2021, Available online: https://doi.org/10.1371/journal.pone.024781

Hussein M. H., Ow S. H., Ibrahim I. & Mahmoud M. A., *Measuring Instructors Continued Intention to reuse Google Classroom in Iraq: A Mixed-Method Study during COVID-19,***Interactive Technology and Smart Education,** 2020. Available online: https://doi.org/10.1108/ITSE06-2020-0095

Iqbal J., Asghar M. Z., Ashraf M. A. & Yi X. T., *The Impacts of Emotional Intelligence on Students' Study Habits in Blended Learning Environments: The Mediating Role of Cognitive Engagement during Covid-19,* **Behavioral Sciences,** 12(1), 2022, 1-19. Available online: doi:https://doi.org/10.3390/bs12010014

Ismail N. S., Abu Bakar N. M. & Wafa S. S. T. S. W. W., *Online Learning Challenges During Pandemic Covid-19 in Malaysian Higher Learning Institution,* **Universal Journal of Educational Research,** 8(12), 2020, 7151 - 7159. Available online: https://doi.org/10.13189/ujer.2020.081282

Ivanov B., *Intersectionality of Gender, Race, Class, Sexuality, Disability and Other Social Identities in Shaping the Experiences and Opportunities of Marginalized Groups in Ukraine,* **International Journal of Gender Studies,** 9(1), 2024, 61 – 74. Available online: https://doi.org/10.47604/ijgs.2357

Jazayeri M. & Li X., *Examining the Effect of Blended Instructional Method on Students' Grades in an Introductory Statistics Course*, **International Journal of Mathematical Education in Science and Technology,** 2020, 1–10. Available online: https://doi.org/10.1080/0020739X.2020.1775319

Jeffrey M. C., Robin L. C., Tawny A. W., Lexie H., Madison L., Wilson J. & Harrison D., *Revisiting Mendel: Use of a Behavioral Assay to Examine Inheritance of Traits in Drosophila,* **Advances in Biology Laboratory Education**, 42, 2022. Available online: https://doi.org/10.37590/able.v42.art56.

Joanna G. & Bergh D., *Adolescent Academic, Social And Future Achievement Goal Orientations: Implications for Achievement by Gender and Parental Education*, **Scandinavian Journal of Educational Research,** 65(5), 2020, 831–850. Available online: https://doi.org/10.1080/00313831.2020.1755360.

Jorge C., *National Achievement Test (NAT) Results and Academic achievement: A Comparative Analysis of Filipino Proficiency across Two Academic Years,* **EPH - International Journal of Humanities and Social Science,** 9(2), 2024, 14–25. Available online: https://doi.org/10.53555/eijhss.v9i2.193.

Jose S. S. & Benjamin E. W., *Factors for Enhancing Achievement In Biology At The Higher Secondary Level,* **International Journal of Early Childhood Special Education** (INT-JECSE), 14(5), 2022, 3934-3942.

Julie B. W., Jones S. & Thornton R., *Boys Lagging behind: Unpacking Gender Differences in Academic Achievement across East Africa,* **International Journal of Educational Development**, 83, 2021, 102382. Available online: https://doi.org/10.1016/j.ijedudev.2021.102382.

Juned A. M., Faizah A. M. & Mustafa S. M. S., *Performance Approach, Mastery Approach, Performance Avoidance and Mastery Avoidance as Predictors of Students' Academic Achievement in English, Mathematics and Science Subjects,* **International Journal of Academic Research in Business and Social Sciences**, 10(11), 2020, 1150-1159. Available online: https://doi.org/10.6007/ijarbss/v10-i11/8190.

Karabatak S. & Polat H., *The Effects of The Flipped Classroom Model Designed according to the Arcs Motivation Strategies On The Students' Motivation ASnd Academic Achievement Levels,* **Education and Information Technologies,** 25(3), 2020, 1475–1495. Available online: https://doi.org/10.1007/s10639-01909985-1

Khoiriyah N. & Pulungan A., *The Effectiveness of Google Classroom In Learning,* **Linguistik Terapan**, 19 (1), 2022, 40-44.

Khushk A., Dacholfany M. I., Abdurohim D. & Aman N., *Social Learning Theory In Clinical Setting: Connectivism, Constructivism, and Role Modeling Approach,* **Health Economics and Management Review**, 3, 2023, 40-50.

Kristiani E., Ristanto R. H. & Lisanti E., *Exploring Gender-Based Biological Concepts: An Analysis of Bilingual Secondary School Students,* **Biosfer : Jurnal Pendidikan Biologi**, 13(1), 2020, 1–13.Available online: https://doi.org/10.21009/biosferjpb.v13n1.1-13

Lalap Jr**.** V. G.**,** *Students' Academic achievement and their Perception on the Use of Google Applications in Social Studies,* **EPRA International Journal of Research and Development (IJRD),** 6(7), 2021, 564 **–** 571. Available online: https://doi.org/10.36713/epra2016

Lawler K. K., Lori K. & Shannon L. G., *Generational Differences among Associate-Degree Health Students: Retention, Academic Achievement, and Learning*

Perceptions, **International Journal of Advanced Academic Studies,** 3(3), 2021, 192–200. Available online: https://doi.org/10.33545/27068919.2021.v3.i3c.600.

Li R., Lund A. & Nordsteien A., *The Link Between Flipped and Active Learning: A Scoping Review,* **Teaching in Higher Education,** *28*(8), 2023, 1993-2027.

Ling F. Y., Zhang Z. & Tay S. Y., *Imposter syndrome and gender stereotypes: Female facility managers' work outcomes and job situations,* **Journal of Management in Engineering**, 36(5), 2020, 04020061.Available online: https://doi.org/10.1061/(ASCE)ME.1943-5479.0000831

Locklear A. K., *Review of Major Learning Theories: A Mind tool for Understanding and Applying Theoretical Concepts.* **J Ment Health SocBehav,** *2*(108), 2020, 1-6.

Lu G., Xie K. & Liu Q., *What Influences Student Situational Engagement in Smart Classrooms: Perception of the Learning Environment and Students' Motivation,* **British Journal of Educational Technology,** *53*(6), 2022, 1665-1687.

Lugosi E. & Uribe G., *Active Learning Strategies with Positive Effects on Students' Achievements in Undergraduate Mathematics Education,* **International Journal of Mathematical Education in Science and Technology,** *53*(2), 2022, 403-424.

Mahjabeen B., Yousuf M. I., Ehsan T. & Hanif M., *Observation of Socio-Emotional Development among Students in Early Childhood Education,* **Qlantic Journal of Social Sciences**, 5(2), 2024, 1-12.

Martha L. A. O., Anthony M. I. & Jotham N. G., *Influence of Subject Area and Level of Academic Achievement on University Students' Propensity for Academic Dishonesty,* **Journal of Education and Practice,** 13, No.21, 2022, 56-63. Available online: DOI: 10.7176/JEP/13-21-07

Matalova E., *Johann Gregor Mendel: Born to Be a Scientist?* **PLOS Biology**, 20(7), 2022, e3001703. Available online: https://doi.org/10.1371/journal.pbio.3001703.

Mehrvarz M., Heidari E., Farrokhnia M. & Noroozi O., *The Mediating Role of Digital Informal Learning in the Relationship Between Students' Digital Competence and their Academic achievement,* **Computers and Education,** 164, 2021, 1-12. Available online: doi:https://doi.org/10.1016/j.compedu.2021.104184

Mkimbili S. T., *Do Biology Syllabi Provide Opportunities for Secondary School Students to Engage with Critical Thinking Skills?,* **Journal of Biological**

Education, 58(2), 2022, 444–459. Available online: https://doi.org/10.1080/00219266.2022.2067582.

Mulvihill J. J. & Wayne W. G., *The Gregor Mendel Bicentennial Tribute—Enduring Mementos of the Founder of Genetics,***JAMA,**330(4), 2023, 297-298. Available online: https://doi.org/10.1001/jama.2023.9766.

Mokhtar R., & Karim M. H. A., *Exploring Students Behaviour in Using Google Classroom During Covid-19 Pandemic: Unified Theory of Acceptance and Use of Technology (UTAUT).* **Journal of Modern Education,** 3(8), 2021, 182-195.

Motz A. A., Quick J. D., Wernert J. A. & Miles T. A., *A Pandemic Of Busywork: Increased Online Coursework following the Transition to Remote Instruction is Associated with reduced Academic Achievement,* **Online Learning,** 25(1), 2021, 70-85. Available online: https://doi.org/10.24059/olj.v25i1.2475

Mozahem N. A., *Using Learning Management System Activity Data to Predict Student Performance in Face-To-Face Courses*, **International Journal of Mobile and Blended Learning,** 12(3), 2020, 20–31. Available online: https://doi.org/10.4018/IJMBL.2020070102

Mpungose C. B. & Khoza S. B., *Postgraduate Students' Experiences on the Use of Moodle and Canvas Learning Management System,* **Technology, Knowledge and Learning,** 2020, Available online: https://doi.org/10.1007/s10758-020-09475-1

Mujahidah N. & Yusdiana Y., *Application of Albert Bandura's Social-Cognitive Theories in Teaching and Learning*, **EdukasiIslami: JurnalPendidikan Islam,** *12*(02), 2023, 2131 – 2146.

Murugesan V., & Santhirasekaran D., *Students' Perception on Using Google Classroom for Learning during Covid-19 Outbreak,* **Asian Journal of English Language and Pedagogy,** 9(1), 2021, 92–101. Available online: https://doi.org/10.37134/ajelp.vol9.1.8.2021

Musa S. & Bello G., *Effects of Metaphor Instructional Strategy on Senior School Students Achievement in Genetics in Ilorin, Nigeria,* **International Journal of Educational Research Review,** 7(3), 2022, 165–175. Available online: https://doi.org/10.24331/ ijere.1098303

Nazrina B., Amelia N., Rejeni M. & Nyuak A., *Machine Learning for Predicting Students' Academic Achievement based on Learning Style and Academic Results,* **International Journal of Innovation and Industrial Revolution,** 5(15), 2023, 120–130. Available online: https://doi.org/10.35631/ijirev.515013.

Nguyen R., *TheIntersectionality of Race, Gender, and Class: Exploring Multiple Dimensions of Inequality.* **Research Consortium Archive,** *2*(01), 2024, 24-30.

Nnodim N. E. & Nwanekezi A. U., *Enhancing Students' Performance in Genetics using 5e Learning Cycle and Webquest in Secondary Schools in Rivers state,* **International Journal of Multidisciplinary Education and Research,** 8(2), 2023, 1-5.

Nurul J. Y. & Ixora S. M., *Challenges towards the Implementation of ICT In Biology Learning: A Review Study*, **1st International Conference on Chemistry And Science Education (IGCSE). Journal of Physics: Conference Series,** 1788, 2021, 1-7.

Ogbe O. O., *Students' Demography Variables and Academic Achievement in Biology in Calabar Municipality Local Government Area of Cross River State,* 2024, 1 – 63. Available online: https://ssrn.com/abstract=4733028

Oguguo B.C.E., Ocheniand A.O & Adebayo F.K., *Students' Achievement in Online Test and Measurement Course in Synchronous and Asynchronous E-Learning Platform.* **European Journal of Open Education and E-learning Studies,** 6(2), 2021, 137-151. Available Online: https://doi.org/10.46827/ejoe.v6i2.3966

Okpokwasili O. A., *Feminist Ethics: A Framework for Gender Justice.* **Nnadiebube Journal of Gender Studies,** *1*(1). 2024, 15 – 26.

Oliveira K. K. D. S. & de Souza R. A. C., *Digital Transformation towards Education 4.0,***Informatics in Education,** 21(2), 2022, 283–309. Available online: https://doi.org/10.15388/infedu.2022.13

Onowugbeda F. U., *Variation and Genetics as Difficult Topics for Secondary School Students in Biology: Exploring the Impact of Indigenous (Cultural) Knowledge for Better Understanding*, **Breaking Barriers to Learning of Science: The CTC Approach,** 2020, 140–154.

Onu W. O., Anyaegbunam N. J. & Uzoigwe A. U., *Improving Biology Students' Interest and Achievement through Collaborative Instructional Strategy*, **Journal of Education Society and Behavioral Science,** 33(2), 2020, 9-20.

Ose-Aigbekaen S. O., *A Survey of Teachers' Knowledge and Characteristics of the New Senior Secondary School Biology Curriculum*, **African Journal of Science, Technology and Mathematics Education (AJSTME)**, 5(1), 2020, 87-93.

Osman Z., Mohamad L. & Mohamad R. K., *Enhancing Students' Online Engagement among Online Distance Learning Institutions' Students in Malaysia. The Role of Digital Readiness as a Mediator,* **Turkish Online Journal of Qualitative Inquiry,** 12, 2021, 9473-9483.

Osuafor A. & Chinasa G. P., *Effect of Flipped Classroom Instruction via Google Classroom on Secondary School Students' Academic Achievement Chemistry in Onitsha Education Zone ,***UNIJERPS Unizik Journal of Educational Research and Policy Studies**, 15(3), 2023, 86 – 95. Available online: http://sjifactor.com/passport.php?id=21363

Palavan O., *The Effect of Critical Thinking Education on the Critical Thinking Skills and the Critical Thinking Disposition of Preservice Teachers*, **Educational Research and Reviews,** 15(10), 2020, 606 – 627.

Paterson T. & Prideaux M., *Exploring Collaboration in Online Group Based Assessment Contexts: Undergraduate Business Program,* **Journal of University Teaching and Learning Practice,** 17(3), 2020.

Permana F. H., Sukma E. & Wahyono P., *The Use of Distance Learning Through Whatsapp and Google Meeting to Identify Differences in Biology Learning Outcomes*, **Biosfer: Pendidikan Biologi,** 14(1), 2021, 86–98. Available online:https://doi.org/10.21009/biosferjpb.20094

Phillip M. B., *The Role of Gender Stereotypes and Societal Pressures in Creating Impostor Syndrome in Black Female Entrepreneurs,* ***Doctoral Dissertations and Projects,*** 2024, 5600. Available online: https://digitalcommons.liberty.edu/doctoral/5600

Putwain D. W., Peter W. & Reinhard P., *Achievement Emotions and Academic Achievement: Reciprocal Relations and the Moderating Influence of Academic Buoyancy*, **Journal of Educational Psychology**, 114(1), 2022, 108–126. Available online: https://doi.org/10.1037/edu0000637.

Qureshi M. A., Khaskheli A., Qureshi J. A., Raza S. A. & Yousufi S. Q., *Factors Affecting Students' Learning Performance through Collaborative Learning and Engagement,* **Interactive Learning Environments**, 31(4), 2023, 2371-2391.

Raheem W., *Gender differences and academic achievement and retention of students in Biology among senior secondary school students in Ekiti State,* **Computers & Education,**9(2), 2019, 104-116.

Ramadhani U. & Syazali A., *The Effect of Flipped-Problem Based Learning Model Integrated with LMS-Google Classroom For Senior High School Students,* **Journal for the Education of Gifted Young Scientists,** 7(2), 2019, 137-158.

Ramlee I., Marinah A., Seow Y. P. & Ridhuan B. A. M., *Active learning in economic subject: A case study at secondary school,* **International Journal of Learning, Teaching and Educational Research,** 19(10), 2020, 19-31. Available online: https://doi.org/10.26803/ijlter.19.10.2

Rincon-Flores E. G. & Santos-Guevara B. N., *Gamification during Covid-19: Promoting Active Learning and Motivation In Higher Education,* **Australasian Journal of Educational Technology,** *37*(5), 2021, 43-60.

Ristanto R. H. & Darmawan E., *Biology reading literacy: Measurement and empowerment through Circ Learning Model*, **Journal for the Education of Gifted Young Scientists,** 8(4), 2020, 1305–1318. Available online:https://doi.org/10.17478/JEGYS.679378

Ristanto R. H. & Mahardika R. D., *Digital Flipbook Immunopedia (DFI): A Learning Media to Improve Conceptual of Immune System,* **Journal of Physics: Conference Series,** 1796(1), 2021, 012-066. Available online: https://doi.org/10.1088/1742-6596/1796/1/012066

Ristanto R. H., Djamahar R., Heryanti E. & Ichsan I. Z., *Enhancing Students ' Biology-Critical Thinking Skill through CIRC-Based Scientific Approach (CIRSA).***Universal Journal of Educational Research,** 8(4A), 2020, 1–8. Available online:https://doi.org/10.13189/ujer.2020.081801

Ristanto R. H., Kristiani E. & Lisanti E., Flipped Classroom–Digital Game-Based Learning (FC-DGBL): Enhancing Genetics Conceptual Understanding of Students in Bilingual Programme, **Journal of Turkish Science Education,** 19(1), 2022, 332-352. Available online: DOI no: 10.36681/tused.2022.124

Ristanto R. H., Miarsyah M., Luthfi I. A., Kristiani E. & Hasanah R., *Invertebrate-Interactive Dichotomous Key Media: Enhance Students Learning Motivation in Lower Secondary School,* **International Journal of Information and Education Technology,** 10(9), 2020, 669–673. Available online: https://doi.org/10.18178/ijiet.2020.10.9.1441

Ristanto R. H., Rahayu S. & Mutmainah S., *Conceptual Understanding of Excretory System: Implementing Cooperative Integrated Reading and Composition Based on Scientific Approach*, **Participatory Educational Research,** 8(1), 2021, 28–47. Available online: https://doi.org/10.17275/per.21.2.8.1

Ristanto R. H., Rusdi R., Mahardika R. D., Darmawan E. & Ismirawati N., *Digital Flipbook Imunopedia (DFI): A Development in Immune System E-LearnSing Media,* **International Journal of Interactive Mobile Technologies (IJIM),** 14(19), 2020, 140. Available online: https://doi.org/10.3991/ijim.v14i19.16795

Rumjaun A. & Narod F., *Social Learning Theory—Albert Bandura,* **Science education in theory and practice: An introductory guide to learning theory**, 2020, 85-99.

Saher N. U., Naz F. & Kamal M., *Mitochondrial DNA Variation and Population Genetic Structure of Mud Crab, Scylla Serrata from Pakistan/Northern Arabian Sea,* **Genetics of Aquatic Organisms,**3(2), 2020,67-77. Available online: https://doi.org/10.4194/2459-1831-v3_2_04.

Samba R. M., Imoko B. I. & Muluku I. A., *Fostering Senior Secondary Students' Attitude and Achievement in Biology in FCT Abuja using Facebook Instructional Strategy*, **British Journal of Education,** 8(3), 2020, 148-160.

Sandybayev A., Mohamed A. S. J. A. & Ahmadi S. A. A. A., *Digital Education: Intensifying Emirati Student's Performance in the Long Run through Hologram Technology,* **Journal of Advances in Humanities and Social Sciences,** 6(4), 2020, 138-146. Available online: doi:https://doi.org/10.20474/jahss-6.4.3

Sari N. M., Yin K. Y. & Zakariya Z., *The Effect of Google Classroom-Assisted Learning on the Academic Achievement of Students,* **International Journal of Academic Research in Business and Social Sciences,** 14(4), 2024, 1 – 16. Available online:http://dx.doi.org/10.6007/IJARBSS/v14-i4/21165

Schneider M. F., *Living Systems Approached from Physical Principles,* **Progress in Biophysics and Molecular Biology** 162, 2021, 2–25. Available online: https://doi.org/10.1016/j.pbiomolbio.2020.10.001.

Senad, *Impact of Google Classroom as an Online Learning Delivery Duringcovid-19 Pandemic: The Case of a Secondary School in Nigeria,* **Journal of Education, Society and Behavioural Science,** 33(9), 2021, 53-61.

Shakoor F., Fakhar A. & Abbas J., *Impact of Smartphones Usage on the Learning Behaviour and Academic achievement of Students: Empirical Evidence from Pakistan,* **International Journal of Academic Research in Business and Social Sciences,** 11(2), 2021, 862– 881. Available online: http://dx.doi.org/10.6007/IJARBSS/v11-i2/8902"

Strawser J. A., Hechavarría D. M. & Passerini K., *Gender And Entrepreneurship: Research Frameworks, Barriers And Opportunities For Women Entrepreneurship Worldwide,* **Journal of Small Business Management,** 59(1),2021, 1–15.Available online: https://doi.org/10.1080/00472778.2021.1965615

Strübel J. & Saheli G., *Clothing And Self-concept In Is gender And Transgender Individuals*, **Gender Issues,** 39(4), 2022, 387-408.

Suleiman S. M. & Akilu I., *Effect of Flipped Classroom Instruction and Enhanced Lecture Method on Academic Achievement In Genetics Among Students With Visual-Auditory-Kinesthetic (VAK) Learning Styles in Gusau, Zamfara State,*

Nigeria, **Journal of Science, Technology and Mathematics Pedagogy,** 1(2), 2023, 1 – 20.

Tabassum N. & Nayak B. S., *Gender Stereotypes And Their Impact on Women's Career Progressions From a Managerial Perspective,* **IIM Kozhikode Society & Management Review**, 10(2), 2021, 192–208. Available online: https://doi.org/10.1177/2277975220975513

Tahir M. H., Adnan M. A. H., YaShak M. S., Shah M. D. S. & Piaralal S. D., *Secondary ESL Teachers use of Google Classroom during COVID-19 pandemic,* **Malaysian Journal of Social Sciences and Humanities (MJSSH),** 7(5), 2022, Available online: https://doi.org/10.47405/mjssh.v7i5.1502

Tarteer S., Badah A. & Khlaif Z.N., *Employing Google Classroom to Teach Female Students During the Covid-19 Pandemic,* **Interdisciplinary Journal of Practice, Theory, And Applied Research,** 2021. Available online: https://doi.org/10.1080/07380569.2021.1988318

Tawalbeh M. A. R., *Quality of Blended Learning as Perceived by Arab Open University Students,* **Journal of Education and Learning (EduLearn),** 14(3), 2020, 449–455.

Teker T., Albayrak G., Akayli T. & Urku C., *Screening of Lactococcal Adhesion Genes and Two Pneumococcal Genes as Genetic Determinants of Virulence in LactococcusGarvieae Strains,* **Genetics of Aquatic Organisms,** 4(2), 2020, 61–67. Available online: https://doi.org/10.4194/2459-1831-v4_2_01.

Thambu N., Prayitno H. J. & Zakaria G. A. N., *Incorporating Active Learning into Moral Education to Develop Multiple Intelligences: A Qualitative Approach,* **Indonesian Journal on Learning and Advanced Education** *(IJOLAE)*, 3(1), 2021, 17-29.

Thapa P., Bhandari S. L. & Pathak S., *Nursing Students' Attitude on the Practice of E-Learning: A Cross-Sectional Survey amid Covid-19 in Nepal.* **PloS One**, 16(6), 2021, 1-17.

Thitipat K. & Phusee-orn S., *Developing Academic Achievement In Mathematics On Fractions through Active Learning Combined with Skill Practice for Grade 3 Elementary Students,* **Higher Education Studies**, 14(2), 2024, 109. Available online: https://doi.org/10.5539/hes.v14n2p109.

Tikhomirova T., Artem M. & Sergey M., *Predicting Academic Achievement with Cognitive Abilities: Cross-Sectional Study across School Education,* **Behavioral Sciences,** 10(10), 2020, 158. Available online: https://doi.org/10.3390/bs10100158.

Türel Y. K. & Dokumaci O., *Use of Media and Technology, Academic Procrastination, and Academic Achievement in Adolescence,* **Participatory Educational Research**, 9(2), 2022, 481–97. Available online: https://doi.org/10.17275/per.22.50.9.2.

Udo U. A., *Effect of Google Classroom on Computer Education Students' Academic Achievement in Colleges of Education South- South, Nigeria,***International Journal of Contemporary Africa Research Network (CARN),** 1(1), 2024, 152 – 173.

Ulum F., *Student Perception of Using Google Classroom in Mathematics Learning in Covid19 Pandemic*, **International Conference on Information System,** 2020, 27-28. Available online: DOI 10.4108/eai.27-10-2020.2304171

Um N., *Learners' Attitude toward E-Learning: The Effects of Perceived System Quality and E-Learning Usefulness, Self-Management of Learning, and Self-Efficacy ,***International Journal of Contents,** 17(2), 2021, 41-47.

Veli B., Topkaya Y. & Jibril S., *The Effect of Project-Based Learning Approach on Students' Academic Achievement: A Mixed Meta-Method,* **Educational Academic Research,** 52, 2024, 176–187. Available online: https://doi.org/10.33418/education.1421193.

Veli B., Yavuz T. & Shafiyu J., *The Effect of Project-Based Learning Approach on Students' Academic Achievement: A Mixed Meta-Method,* **Educational Academic Research,** 52, 2024, 176–187. Available online: https://doi.org/10.33418/education.1421193.

Vlădescu C., *The Relationship between Mastery Learning Models and Academic Achievement in Mathematics,* **International Electronic Journal of Mathematics Education**, 18(4), 2023, em0751. Available online: https://doi.org/10.29333/iejme/13705.

Vo M. H., Zhu C. & Diep A. N., *Students' Performance in Blended Learning: Disciplinary Difference and Instructional Design Factors,* **Journal of Computers in Education,** 7(4), 2020, 487–510. Available online: https://doi.org/10.1007/s40692-020-00164-7

Webster A. K. & Patrick C. P., *Heritable Epigenetic Variation Facilitates Long-Term Maintenance of Epigenetic and Genetic Variation*, **Edited by IKronholm. G3: Genes, Genomes, Genetics** 14(2), 2023, 1-15Available online: https://doi.org/10.1093/g3journal/jkad287.

Widiyatmoko A., *The Effectiveness of Google Classroom as a Tool to Support Online Science Learning: A Literature Review,* **Journal of Physics: Conference Series,** 2021. Available online: https://doi.org/10.1088/1742-6596/1918/5/052069

Xiaocui X., *Students' Attitudes and Academic Achievement in Learning Calculus*, **Frontiers in Educational Research**, 7(2), 2024, 41-46. Available online: https://doi.org/10.25236/fer.2024.070207.

Yue Z., *A Study on Academic Optimism on the Academic Achievement of Secondary Education School in China*, **Journal of Digitainability, Realism & Mastery (DREAM)**, 1(5), 2022, 1–10. Available online: https://doi.org/10.56982/dream.v1i05.45.

Zhao Y., Llorente A. M. P. & Gómez M. C. S., *Digital Competence in Higher Education Research: A Systematic Literature Review,* **Computers and Education,** 168, 2021, 1-14. Available online: doi:https://doi.org/10.1016/j.compedu.2021.104212

Dissertation

Ibadan North LGA Local Inspection of Education (LIE), *Public Secondary Schools SS II Enrolments in the twelve wards of Ibadan North Local Government Area*, Oyo state, 2024

Ibitoye T. M., *Project-Based Learning and Self-Regulatory Strategies as Determinants of Secondary School Students' Achievement, Attitude and Practical Skills in Biology Concepts in Ibadan, Nigeria,* 2021, 1 – 196.

Appendix I
Genetics in Biology Achievement Test (GBAT)

Instructions:

In Section A: Please provide an appropriate answer to the following questions
In Section B: Please shade only one answer at a time from the given options
Duration: 1 hour

Section A
Demographic Characteristics of Participants

School Name: _____

Gender: Male ☐ Female ☐

Class: _____

Group Type: Group A ☐ Group B ☐ Group C ☐

Test Type: Pre-test ☐ Post-test ☐

Section B

1. The F_1 generation of a cross between a red flower and a white flower of the same species were all red because the gene for the
   (a) White colour did hot segregate
   (b) Red colour was dominant
   (c) White colour was dominant
   (d) Red colour was recessive
   (e) White colour was recessive

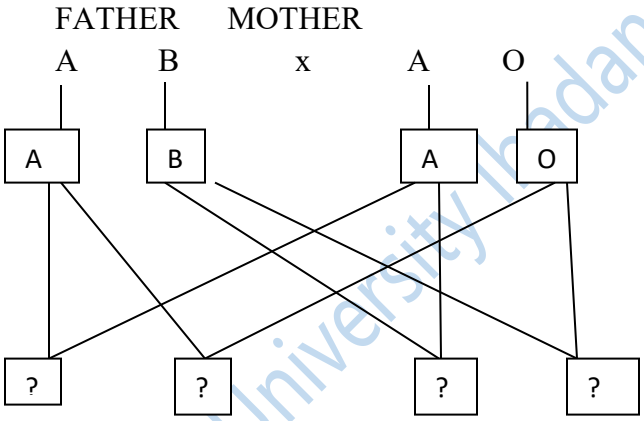
2. In Mendel's experiment on monohybrid crossing, the result of the F_1 generation was that
   (a) ½ of the offspring showed the dominant trait
   (b) ¾ of the offspring showed the dominant trait
   (c) All the offspring showed the dominant trait
   (d) ¼ of the offspring showed the dominant trait
   (e) None of the offspring showed the dominant trait

3. When homozygous dominant and heterozygote organisms are crossed over two generations, the dominant trait will appear in
   (a) The F_1 generation only
   (b) The F_2 generation only
   (c) Both the F_1 and F_2 generations
   (d) One offspring of the F_2 generation only
   (e) One offspring of the F_1 generation only

4. When gamete from pure breeding,parents with contrasting features such as tallness and shortness are involved in monohybrid cross, the offspring in the first fillia generation are usually
   (a) Pure breed
   (b) Heterozygous dominant
   (c) Homozygous recessive
   (d) Mutants
   (e) Co-dominant

5. One of the major criticism of Mendelians law is that they do not recognise that
   (a) One traits is often controlled by many pairs of genes
   (b) Singe factor inheritance is never a reality
   (c) Complete dominance is always possible
   (d) Incomplete dominance is not possible
   (e) Hybrids exist in living organisms

   Study the genetic cross below showing the inheritance of blood groups



6. From the cross above, which of the F1 offspring does not belong to the father?
   (a) AA
   (b) AO
   (c) OB
   (d) OO
   (e) AB

7. The genotypic ratio of 1:2:1 in the offspring of a hybrid cross illustrates
   (a) Use and disuse
   (b) Dominance
   (c) Segregation
   (d) Linkage
   (e) Pollution
8. The carrier of the hereditary character in plant and animals is the

(a) Cell
(b) Nucleus
(c) Chromosome
(d) Chloroplast
(e) Gene

9. The hereditary material in a cell is
(a) ADP
(b) CNS
(c) RNA
(d) ATP
(e) DNA

10. The DNA molecule is a chain of repeating
(a) Nucleosides
(b) Nitrogenous bases
(c) Sugar Phosphate
(d) Nucleotides
(e) Mitochondrion

11. According to Mendel's first law of inheritance , segregation of genes occur when
(a) Tall plants are crossbred
(b) Short plants are crossbred
(c) Tall plants and short plants are crossbred
(d) Plants are crossbred
(e) None of the above

12. The greatest contributions to genetic studies was made by
(a) Gregor Mendel
(b) Thomas Morgan
(c) Charles Darwin
(d) Robert hooke
(e) Charles Mendel

13. The cross between RrTt and rrtt where R is a gene for red colour and T for tallness will result in
(a) All the offspring being tall with red fruits
(b) 25% tall with red fruits
(c) 50% tall with red fruits
(d) 100% tall with no red fruit

(e) 75% tall with red fruits

14. The process that gives rise to F_1 generation is
    (a) Pollination
    (b) Self-fertilization
    (c) Cross fertilization
    (d) Out-breeding
    (e) Test cross

15. If two parents are sickle cell carriers, then their genotypes would be
    (a) Hb^AHb^A and Hb^SHb^S
    (b) $Hb^SHb^S$and Hb^SHb^S
    (c) Hb^AHb^S and Hb^AHb^S
    (d) Hb^AHb^A and Hb^AHb^A
    (e) Hb^SHb^S and Hb^SHb^S

16. In case of complete dominance, what is the phenotypic ratio of the cross Bb X Bb; where B=black and b=white?
    (a) 1 black : 1 grey : 2 whites
    (b) 1 black : 3 white
    (c) 1 black: 2 blues: 1 white
    (d) 3 blacks:1 white
    (e) 2 grey :2 whites

17. What will be the phenotypic ratio of offspring of a cross between a heterozygous dominant parent and a double recessive parent?
    (a) 1:2:1
    (b) 1:1
    (c) 4:0
    (d) 3:1
    (e) 2:1

18. When Mendel crossed round seeds with wrinkled seeds of pea plant, what was the ratio of wrinkled seeds to round seeds in the F_1 plants
    (a) 3:2
    (b) 3:1
    (c) 1:3
    (d) 1:2
    (e) 2:1

Use the following information to answer question 19 and 20

In an experiment, a red Flower plant was crossed with another red flowered plant and the following results were obtained:448 red flowers and 154 white flowers in the F_1generation

19. Which of the following represent the genotypes of the parents if R is for red gene and r for white gene?
    (a) RR=Rr
    (b) RR=rr
    (c) Rr=rr
    (d) Rr=Rr
    (e) RR=RR

20. Which of the following represent phenotypic ratio of the above genetic cross?
    (a) 1:2:1
    (b) 4:1
    (c) 3:1
    (d) 2:2
    (e) 4:2

21. Which of the following is a function of chromosome?
    (a) Transmission of hereditary trait
    (b) Protein synthesis
    (c) Excretion
    (d) Energy production
    (e) Manufacture of enzyme

22. Which of the following statement is correct about gene? They
    (a) Diminish with ageing
    (b) Remain constant throughout life
    (c) Are usually affected by the environment
    (d) Changes colour
    (e) Grow with ageing

23. The simplest unit of transfer of character from parents to offspring is the
    (a) Chromosome
    (b) Gene
    (c) DNA
    (d) Ribosome
    (e) Nuceic
24. In the structure of DNA, which of the statements is correct?
    (a) The double helix are held together by covalent bond

(b) Adrenaline is the opposite of nucleic
(c) Nucleotide is made up of ribose, phosphate and an organic nitrogen compound
(d) Guanine is the opposite of cytosine
(e) Adenine is the opposite of cytosine

25. The chemical bond that holds the two bases of the two strands of DNA together is
(a) Covariance bond
(b) Oxygen bond
(c) Hydrogen bond
(d) Electrovalent bond
(e) Covalent bond

26. What is the probability of a man of blood group AB married to a woman of blood group O producing a child of blood group O?
(a) 0%
(b) 25%
(c) 50%
(d) 100%
(e) 75%

27. Which of the following chromosome combinations will produce a baby girl?
(a) XY
(b) XX
(c) YY
(d) YX
(e) XYX

28. Blood grouping in human beings is derived from combinations of
(a) Two different alleles
(b) Three different alleles
(c) Four the same alleles
(d) Four different alleles
(e) Two diffent genes

29. Which of the following is true about blood groups and blood transfusion?
(a) Group O is the universe recipient
(b) Group A can donate to group A only
(c) Group AB is the universal recipient
(d) Group B can donate to group B only
(e) Group O can donate to B only

30. If the pair of alleles for baldness is given as Bb, a female carrier will be donated by
    (a) X^BX^b
    (b) X^BX^B
    (c) X^{by}
    (d) X^{BY}
    (e) X^bX^b

Appendix II
Teaching and Learning Activities Guides (TLAG)

Activities Guide for Experimental Group A
Lesson Note I
Genetics in Biology - Flipped-Google Classroom with Collaboration

School: As Applicable

Subject: Biology

Class: SSII

Topic: Genetics

Number in Class: As Applicable

Gender: Mixed

Duration: 80 Minutes

Date: As Applicable

Instructional Objectives:

At the end of the lesson, students should be able to:

i. Understand the key concepts in Genetics.
ii. Facilitate collaborative learning through the Flipped Classroom Model and Google Classroom.

Presentation:

Pre-Class Activities (Flipped Learning)		
Activities	**Description**	**Details**
Activity 1	Introduction to Genetics	Watch the assigned video lecture on basic genetics concepts, including DNA structure, gene expression, and genetic inheritance patterns. Take notes and review the accompanying materials.
Activity 2	Exploration of Genetic Traits	Complete the online interactive activity exploring genetic traits and inheritance patterns in humans and other organisms. Record observations and findings.
Activity 3	Reading Assignment	Read the assigned articles or textbook chapters on

		Mendelian genetics, genetic variation, and modern applications of genetics in biotechnology and medicine. Reflect on key concepts and questions.
In-Class Activities (Collaborative Learning)		
Activities	**Description**	**Details**
Activity 1	Group Discussions	Form small groups and engage in guided discussions on the pre-class materials. Discuss key concepts, clarify doubts, and share insights with your peers.
Activity 2	Case Studies	Analyze real-world case studies related to genetic disorders, genetic engineering, or evolutionary Biology. Work together to identify the underlying genetic principles and propose potential solutions or interventions.
Activity 3	Problem-Solving Exercises	Collaborate on problem-solving exercises or simulations that require applying genetics principles to solve genetic problems or analyze experimental data.
Activity 4	Interactive Presentations	Prepare and deliver short presentations on assigned genetics topics, sharing your research findings, insights, and reflections with the class. Use multimedia tools and visual aids to enhance understanding.
Activity 5	Peer Review and Feedback	Provide constructive feedback to your peers on their presentations, projects, or problem-solving solutions. Offer suggestions for improvement and encourage active participation.
Post-Class Activities		
Activities	**Description**	**Details**
Activity 1	Reflection and Synthesis	Reflect on your learning experience and synthesize key

		genetics concepts covered in the lesson. Write a brief reflection journal or summary of your understanding.
Activity 2	Case Studies	Analyze real-world case studies related to genetic disorders, genetic engineering, or evolutionary Biology. Work together to identify the underlying genetic principles and propose potential solutions or interventions.
Activity 3	Assessment	Explore additional resources or extension activities related to genetics that interest you. Share your findings with the class through Google Classroom or in-class discussions.

Conclusion:

By actively engaging in pre-class preparation, collaborative in-class activities, and post-class reflection, you will deepen your understanding of genetics and develop important critical thinking and collaboration skills. Remember to continue exploring and applying genetics concepts in your studies and daily life.

Appendix III

Teaching and Learning Activities Guides (TLAG)
Activities Guide for Experimental Group B
Lesson Note II
Genetics in Biology - Flipped-Google Classroom without Collaboration

School: As Applicable

Subject: Biology

Class: SSII

Topic: Genetics

Number in Class: As Applicable

Gender: Mixed

Duration: 80 Minutes

Date: As Applicable

Instructional Objectives:

At the end of the lesson, students should be able to:

i. Understand the key concepts in Genetics.
ii. Facilitateindependent learningthrough the Flipped Classroom Model and Google Classroom.

Presentation:

Pre-Class Activities (Flipped Learning)		
Activities	**Description**	**Details**
Activity 1	Introduction to Genetics	Watch the assigned video lecture on basic genetics concepts, including DNA structure, gene expression, and genetic inheritance patterns. Take notes and review the accompanying materials.
Activity 2	Exploration of Genetic Traits	Complete the online interactive activity exploring genetic traits and inheritance patterns in humans and other organisms. Record observations and findings.
Activity 3	Reading Assignment	Read the assigned articles or

		textbook chapters on Mendelian genetics, genetic variation, and modern applications of genetics in biotechnology and medicine. Reflect on key concepts and questions.
In-Class Activities		
Activities	**Description**	**Details**
Activity 1	Guided Practice	Engage in guided practice activities to reinforce genetics concepts covered in the pre-class materials. Complete worksheets, problem sets, or online quizzes to assess your understanding.
Activity 2	Teacher-led Discussion	Participate in a teacher-led discussion on the pre-class materials. Ask questions, seek clarification, and discuss challenging concepts with your instructor and classmates.
Activity 3	Review Session	Review key genetics concepts and address any misconceptions or areas of confusion identified during the pre-class activities. Collaborate with peers to clarify doubts and reinforce learning.
Activity 4	Application Exercises	Apply genetics principles to solve real-world problems or analyze experimental data. Work independently or in pairs to complete application exercises or case studies.
Post-Class Activities		
Activities	**Description**	**Details**
Activity 1	Reflection and Synthesis	Reflect on your learning experience and synthesize key genetics concepts covered in the lesson. Write a brief reflection journal or summary of your understanding.
Activity 2	Extension Activities	Explore additional resources or extension activities related

		to genetics that interest you. Share your findings with the class through Google Classroom or in-class discussions.
Activity 3	Assessment	Complete the assigned quiz or assessment on genetics concepts covered in the lesson. Use the feedback provided to identify areas for further review or improvement.

Conclusion:

By actively engaging in pre-class preparation and independent learning activities, you will deepen your understanding of genetics and develop important critical thinking skills. Remember to continue exploring and applying genetics concepts in your studies and daily life.

Appendix IV
Teaching and Learning Activities Guides (TLAG)
Activities Guide for Control Group C
Lesson Note III
Genetics in Biology - Traditional Teaching Strategy

School: As Applicable

Subject: Biology

Class: SSII

Topic: Genetics

Number in Class: As Applicable

Gender: Mixed

Duration: 80 Minutes

Date: As Applicable

Instructional Objectives:

At the end of the lesson, students should be able to:

i. Understand the key concepts in Genetics through traditional teaching methods, including lectures, discussions, and hands-on activities.

Presentation:

Activities	Description	Details
Activity 1	Introduction to Genetics	- Begin the lesson by providing an overview of genetics and its significance in Biology. - Define key terms such as DNA, genes, alleles, genotype, and phenotype. - Discuss the historical development of genetics, including contributions from scientists such as Gregor Mendel and Watson and Crick.
Activity 2	Lecture on Mendelian Genetics	- Deliver a lecture on Mendelian genetics, focusing

		on Mendel's principles of inheritance. - Explain the concepts of dominance, segregation, and independent assortment. - Use visual aids such as diagrams and charts to illustrate Mendel's experiments and results.
Activity 3	Discussion on Genetic Variation	- Facilitate a class discussion on genetic variation and its sources, including mutations, genetic recombination, and gene flow. - Encourage students to share examples of genetic variation in different organisms and populations.
Activity 4	Hands-on Activity: Punnett Squares	- Conduct a hands-on activity on Punnett squares to illustrate genetic crosses and predict offspring genotypes and phenotypes. - Provide worksheets or materials for students to practice solving Punnett square problems individually or in pairs.
Activity 5	Introduction to DNA Structure	- Introduce the structure and function of DNA, including the double helix structure and the role of DNA in storing genetic information. - Discuss the process of DNA replication and its significance in genetic inheritance.
Activity 6	Case Study: Genetic Disorders	- Present case studies of genetic disorders such as sickle cell anemia, cystic fibrosis, and Huntington's disease. - Discuss the genetic basis of these disorders, inheritance patterns, and potential treatments or interventions.

Activity 7	Review and Assessment	- Review key concepts covered in the lesson through a brief summary or review activity. - Administer a quiz or assessment to evaluate student understanding of genetics concepts and principles. - Provide feedback and guidance to students to address any misconceptions or gaps in understanding.

Conclusion:

By engaging in lectures, discussions, and hands-on activities, students will develop a solid understanding of key concepts in Genetics and their significance in Biology. Encourage students to continue exploring Genetics topics and their applications in future lessons and independent study.

Bio–data

A. Personal Data

Full name:	Damilola Jumoke IBIYEMI
Email:	ibiyemidamilola5@gmail.com
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Name and Address of Next of Kin:	Mr Eyitayo Ibiyemi Plot 4, Akanbi layout,Bodija Ibadan

B. Educational Background with Dates

Lead City University, Ibadan M.phil Biology Education (In View)	2022 till Date
University of Ibadan, Ibadan M.Ed Biology Education	2015
University of Ibadan, Ibadan B.Ed Biology	2009
School of Science, Ile Ife Senior Secondary School Certification	2003

C. Working Experiences with Dates

Ilesa Grammar School, Ilesa Osun state PTA Class Teacher/Subject Teacher	2010–2012
Smart School, University of Ibadan Second gate Class Teacher /Subject Teacher	2013–2014
Gods' Grace Kiddies Institute Class teacher	2014-2015

Glorious Kings Palace Academy
Proprietor 2016 till date

D. Awards and Fellowships (If any)

E. Membership of Professional Bodies

Teachers Registration Council of Nigeria (TRCN) 2019

National Youth Service Corps (NYSC) 2012

National Association of Proprietor Private Schools (NAPPS) 2016

F. Publications

1. Thesis Dissertation: Effects of Digital Learning Platforms on Academic Achievement on academic Achievement of Secondary School Students in Genetics in Ibadan North Local Government of Oyo State

2. Students' Attitude Towards Biology Practical as Correlate to Academic Achievement in Biology Among Senior Secondary School Students In Ilesa, Osun State

3. Level of Science Process Skills and Efficient Laboratory Use Towards Biology Practical as Correlate to Academic Achievement in Biology in Ilesa, Osun State

4. Effect of Flipped Classroom Learning on Academic Achievement of Senior Secondary School Students in Biology in Ibadan North Local Government

G. Major Conferences Attended with Dates

i. Attended the Lead City University Postgraduate Conference, themed "Innovative Research and Quality Education for Sustainable Development" October 16th-19th,2023
ii. Attended the Lead City University, Faculty of Education, 1stFaculty Symposium themed "Dynamics of a Good Research Problem Statement and Plausible Recommendations for New Knowledge" June 13th 2024

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_____ _____

Signature **Date**

The University Compliance Certification

This is to certify that this thesis by Damilola Jumoke IBIYEMI with the Matric number LCU/PG/003962 in the Department of Science Education, Faculty of Education, Lead City University, Ibadan, Oyo State is in full compliance with the approved University format and style.

_____ _____

Signature **Date**