Chapter One

Introduction

1.1 Background to the Study

The swiftly changing environment of education highlights the essential requirement to investigate creative teaching strategies that enhance student engagement, critical thinking, and a profound comprehension of the subject matter. In a literature, there has been a growing emphasis on enhancing educational quality through the implementation of innovative and effective teaching strategies aimed at fostering learning. Among these strategies, concept mapping and cooperative learning have emerged as promising tools to enhance student learning outcomes. For students focussing on Biology, establishing a robust understanding of the subject is crucial, as they hold the important role of influencing the scientific literacy of future generations. Utilising concept mapping and cooperative learning strategies can significantly enhance students' understanding and achievement in Biology. These strategies promote active engagement among learners, foster collaboration, enhance critical thinking, and facilitate the development of advanced cognitive skills.

The importance of receiving a quality education in Biology cannot be overestimated since it is the cornerstone of establishing scientific literacy and gaining a grasp of significant ecological, health, and environmental concerns. On the other hand, conventional strategys of education would not always thrive in complete engagement of learner in class activities foster understanding and information retention. Educators and researchers have turned their focus to concept mapping and cooperative learning as a means of unraveling students potentials as means of fostering active learning, critical thinking, and collaborative abilities among Biology students.

The academic performance of students in cell biology significantly impacts the quality of instruction they deliver in the classroom. To enhance effective scientific teaching in educational institutions, it is crucial to guarantee that future educators in Biology possess a strong grasp of the subject matter. However, the use of instructional strategys such as concept mapping and the cooperative learning strategy by educators at colleges of education in the context of teaching Biology enhances the academic achievement of students[1]. Students at the Federal College of Education denote persons who are undergoing preparation to get licensure as teachers or educators. These individuals are generally enrolled in teacher training programmes at colleges, universities, or other educational institutions. Programs at the Federal College of Education are structured to provide prospective educators with the essential information, skills, and competencies required for effective teaching in diverse educational environments[2].

The pursuit of knowledge in biological science is crucial for improving quality of life, as it provides insights into living organisms and their complex interactions with the environment. The pursuit of knowledge and skill development in Biology enhances scientific literacy and aids in understanding our environment. Moreover, these competencies offer substantial advantages to both individuals and society, as they actively contribute to the promotion of the nation's socio-economic progress[3]. Despite the significance of Biology, there has been a notable decline in student's achievement specifically in the field of Cell Biology within various colleges of education in the Southwestern, Nigeria. For instance, the proportion of students who successfully passed Cell Biology in these colleges appears to be considerably lower when compared with the overall student's population. This scenario is disheartening and, if left unattended to, could yield significant effect on the entire educational system[4].

Previous studies have demonstrated that students possess a considerable number of misconceptions regarding many topics within the field of Biology, such as photosynthesis, ecology, genetics, evolution, and cell biology, among others[5,6]. Cell Biology, a fundamental discipline within the study of Biology that investigates the interconnectedness of living organisms, has witnessed significant advancements in the last two decades due to the progress made in several scientific domains such as electron microscopy, biochemistry, and immunology. The course Cell Biology offered in colleges of education covers the following topics: Cell theory, the structure of plant and animal cells and their comparison. It offers numerous advantages to students in comprehending Biology as a comprehensive discipline, as it serves as the fundamental basis for the biological sciences and aids in addressing diverse societal issues[6].

Cell Biology is the scientific discipline that focuses on examining the structure and functioning of cells, which are the fundamental unit of life. The objectives of the Cell Biology course include gaining a comprehensive understanding of cell and cell theory, exploring the historical background of cell research, and conducting a comparative analysis of animal and plant cells based on their contents, among other topics. One of the goals of Cell Biology is to explore new fields of study, such as microbiology, forensic science, biotechnology, medicine, biomedical engineering, cytology and biochemistry. Forensic medicine employs the fields of Cell Biology and DNA fingerprinting to aid in the resolution of homicides and physical attacks. Both the judicial system and the offenders cannot evade the significance of Cell Biology[6].

Biotechnology employs strategyologies and knowledge derived from Cell Biology to manipulate the genetic makeup of crops, resulting in the development of alternative traits. It also encompasses the replication of plants and animals through cloning techniques. Furthermore, biotechnology aims to enhance the accessibility of high-quality food at reduced expenses and the production of more refined pharmaceuticals and eventually, organs for individuals requiring transplants. Cell Biology encompasses several topics and can lead to a stimulating profession. It is crucial for everyone to be well-informed about the potential impact of advancements in Cell Biology on themselves and society as a whole. Society must make well-informed choices on the cultivation of organs for human transplantation and the development of genetically modified rice that produces vitamin 'A' to address blindness caused by vitamin shortage. This development facilitated the direct examination of cellular processes and progress on a conceptual and theoretical level[6].

Hence, it is imperative that the field of Cell Biology be incorporated into the fundamental scientific education of all individuals in the 21st century. The idea of cell poses significant challenges and learning barriers for students. The definition of the science of Cell Biology has challenges, mostly due to the abstract nature of cell as a fundamental entity in terms of structure and function. Cell is seen as a metaphysical idea, lacking tangibility and visibility, and its study relies heavily on microscopic observation[6]. This difficulty will undoubtedly create in the learners a false understanding of the basic concepts of Cell Biology and will emerge false ideas, erroneous conceptions, and unsurpassable misconceptions that block good learning in Biology. However, several studies that have focused on the teaching of Cell Biology and educational innovations have shown that this discipline generates learning difficulties for Biology students, which will constitute potential obstacles to the assimilation and understanding of concepts of other biological disciplines[1,7]. As a result, the underachievement of students may be associated with the inappropriate, insufficient, and exclusive teaching strategies and strategys employed by Biology educators[1,7]. To tackle this challenge, it is advisable for Biology educators to utilise teaching strategy that foster active participation among students, especially when covering intricate and abstract subjects like Cell Biology.

Among the strategies that can be employed and extensively studied in recent times are Concept Mapping Strategy (CMS) and Cooperative Learning Strategy (CLS). These two strategies have demonstrated significant efficacy and widespread adoption which is why this present study deem it fit to consider them as proactive measures to teaching of Cell Biology to pre-service Biology teachers[7].

Concept mapping serves as a cognitive learning strategy that enables individuals to visually articulate and structure their knowledge in a hierarchical manner. When learners deconstruct extensive information into digestible segments of concepts and connections, they enhance their capacity to comprehend and remember the material. Students in biological sciences could gain advantages from concept mapping as it promotes reflective thinking, thereby aiding them in linking theoretical concepts to practical applications in the real world.

Concept mapping serves as a meta-cognitive learning technique that evaluates how an individual organises and structures their knowledge within a specific domain. The terms "cognition about cognition," "knowing about knowing," and "thinking about thinking" all refer to the concept of meta-cognition. Concept mapping serves as a technique for illustrating the relationships among concepts within a two-dimensional framework. A concept map illustrates a collection of interconnected concepts, highlighting the relationships between pairs of concepts through the links that bind them. A valuable technique for demonstrating ideas within a topic or unit and their interrelations in a two-dimensional format is concept mapping. The map serves as a tool for both the instructor and the students to illustrate their perspectives on a range of topics and the relationships between them. Concept mapping is an instructional strategy that has demonstrated its effectiveness in improving both teaching and learning across various disciplines. Concept mapping can be referred to by various terms such as cognitive mapping, mental mapping, concept webbing, concept trees, knowledge maps, clinical correlation maps, structured note taking, and flow charting, based on its specific application. These phrases all relate to the concept of visually representing interconnected subjects[8].

Concept mapping serves as a cognitive instrument that visually represents the hierarchical structure of information, concepts, and their interrelations. Studies in the field of science education, particularly within Biology, showed that using concept mapping as a teaching strategy has proven effective in promoting positive teaching and learning results across different educational stages, from primary school to university. Concept maps serve as an essential tool for promoting meaningful learning, assessing understanding, developing instructional strategyes, and uncovering alternative conceptions or misconceptions that learners may possess. The use of concept mapping as a learning tool demonstrates a lasting effect on memory, evidenced by enhanced performance on delayed post-tests in comparison to other teaching and learning strategys. Furthermore, it is worth noting that the integration of manipulative learning tactics, such as experiments, might enhance the effectiveness and utility of this strategy.

Additionally, concept mapping offers students with a visual depiction of a certain subject area, which may help them make more effective use of the resources that are at their disposal. When looking at the map, he or she might be able to identify the primary ideas, sort them in descending order from more broad to more detailed, and establish meaningful connections between the various ideas. Therefore, concept mapping is an effective yet straightforward strategy of utilising diagrams to display information in the same manner that one thinks about it. Through the use of concept mapping, difficult material may be easily comprehended, remembered and communicated. The position of the teacher in his/her environment has evolved from that of a knowledge-transmitter to that of a facilitator[8].

Conversely, cooperative learning environments are developed through the implementation of cooperative learning techniques, which promote collaboration among students to achieve shared educational goals. By facilitating interaction and dialogue among the individual in question, this strategy contributes to the development of a community of Biology students that are both intellectually stimulating and emotionally supportive. This community fosters individual development while also strengthening the unity of the group. In various educational environments, learners can significantly improve their understanding, problem-solving abilities, and overall academic success when this collaborative learning strategy is implemented. This enhancement may arise from heightened student involvement[4].

The term cooperative learning strategy refers to a teaching strategy that integrates aspects of both cooperative learning and mastery learning strategies into a single educational strategy. Learners are likely to be more motivated as a result of this strategy since it incorporates the advantages of mastery learning and cooperative learning. This strategy has long had a reputation for being a successful teaching strategy due to the participatory character of the strategy. This strategy guarantees a balance of mutual reliance and personal responsibility, where the achievements of one or a collective of students facilitate the success of others. It fosters concepts of collaborative leadership and accountability by engaging students in problem-solving within teams or groups under specific circumstances. It involves having students collaborate on the problem in teams or groups within specific parameters. Furthermore, earlier studies indicated that employing a collaborative strategy often enhanced students' engagement, focus, and enthusiasm in the classroom[4].

Cooperative learning is an educational strategy that positions students at the core of the learning experience, while the instructor acts as a facilitator. This strategy entails structuring students into small teams, encouraging them to take ownership of their own education while also supporting the learning of their peers within the group. This educational strategy involves the deliberate organisation of students into small groups, wherein they collaborate and support each other in the acquisition of academic knowledge and the achievement of shared objectives. The educator has the responsibility for managing and regulating the educational setting, devising instructional tasks and fostering social engagements and organising collaborative groups. This strategy encourages the active participation of every student in the group, promoting teamwork and shared effort that deepens understanding of the topic. An essential component of cooperative learning involves incorporating group collaboration and establishing collective objectives. Cooperative learning involves a range of structured and unstructured strategy, often featuring intentional teacher involvement to enhance student participation and promote successful learning results[9].

Cooperative learning offers a range of benefits. Cooperative learning utilises goal interdependence and resource interdependence to enhance interaction and communication among individuals in a group.. Shifting the instructor's position from a traditional lecturing strategy to that of a facilitator for students groups contributes to the cultivation of a social learning environment, whereby students engage in interactive learning experiences. Cooperative learning fosters the cultivation of amicable relationships among students and facilitates the enhancement of social and communication skills and the promotion of enhanced tolerance and acceptance of difference among peers. The strategy encourages the active engagement of students in the process of constructing knowledge, so as to foster the development of their interest in the subject matter[10].

In a few studies, the researchers were particularly interested in determining how concept mapping and cooperative learning tactics affect the overall achievement of Biology students. Studies have observed that students' grasp of biological concepts and their ability to remember such concepts increased when cooperative learning was employed in conjunction with concept mapping. In addition to more in-depth comprehension of the subject matter, the students shown considerable gains in their ability to think critically about the concept[11]. Furthermore in another study, a researcher used concept mapping and collaborative teaching to encourage conceptual shifts in Biology among future educators. The outcome of the study in the example showed that when two strategies were used together, students conceptual knowledge increased significantly and their misunderstandings about biological topics were reduced. The study in the example also showed that, improved conversation and teamwork were other benefits of cooperative learning setting[12].

A separate investigation examined the effects of various instructional strategies, including concept mapping and cooperative learning, on Biology students' comprehension of biological concepts. The findings from the study indicated that when students were instructed using a blend of these strategies, they demonstrated improved retention of knowledge, enhanced critical thinking skills, and a greater ability to apply biological concepts to real-world situations. Furthermore, the reports from students indicating a rise in their interest and enjoyment in academic pursuits are quite promising[13]. A study was carried out to assess the impact of concept mapping and cooperative learning on the academic performance of Biology students and their attitudes towards the subject. The results indicated that the combined strategy positively impacted students' academic performance and fostered a more positive attitude towards Biology. The students indicated a heightened sense of satisfaction with the teaching experience, resulting in elevated levels of motivation[14].

Long-standing observations have highlighted the existence of gender disparities in science education, particularly in the field of Biology, and these issues persist in the present day[15]. A review of study indicated that disparities in student achievement based on gender persist, largely due to the teaching strategies employed by educators[16]. Considering these variations and the differences in students' learning strategies to Biology, it is essential for educators in this field to recognise and address this factors effectively.

While some studies emphasise the advantages of implementing concept mapping and cooperative learning strategies in the teaching of Biology for students in Federal Colleges of Education in Southwest, Nigeria. The integration of these teaching strategies seems to improve students' grasp of concepts, foster critical thinking abilities, boost motivation, and positively influence their attitudes towards the subject. Given the positive outcomes demonstrated by these studies, it is logical to contemplate the implementation of such strategies in teacher training programmes to enhance the preparation of future educators in the field of Biology. This study aims to explore the impact of concept mapping and cooperative learning strategies on the academic achievement of Federal Colleges of Education students in Cell Biology in Southwest, Nigeria.

1.2 Statements of the Problem

The education system is fundamental in developing the knowledge and skills of future educators, especially those studying Biology. In Southwestern Nigeria, the quality of science education, particularly in Biology, has raised concerns due to numerous challenges encountered by students in this field. The existing strategies to instructing Biology students appear to fall short in effectively engaging them or sufficiently meeting their educational requirements. Additionally, various factors have been recognised as the root causes of students' academic underperformance in the discipline of Biology. College of Education Biology students often believe that the subject demands a significant amount of reading, which they find to be quite challenging. Elements like the degree of engagement among students, inadequate and low-quality practical sessions in the laboratory, oversized class sizes in Biology classrooms, an environment, and ineffective teaching strategies may significantly impact academic achievement in cell Biology. Consequently, these upcoming pre-service teachers might find it challenging to convey scientific knowledge effectively to their students, which could impede the overall quality of science education. This study explored the effects of concept mapping and cooperative learning strategies on the academic achievement of Federal Colleges of Education students in Cell Biology in Southwest, Nigeria.

1.3 Aim and Objectives of the Study

The study aimed to determine the effects of concept mapping and cooperative learning strategies on Federal Colleges of Education students Academic Achievement in Cell Biology in Southwest, Nigeria**.** The objectives of the study are to:

i. determine the main effect of concept mapping strategy on Biology students' academic achievement when taught Cell Biology at Federal College of Education in Southwest, Nigeria;
ii. determine the main effect of cooperative learning strategy on Biology students' academic achievement when taught Cell Biology at the Federal College of Education in Southwest, Nigeria;
iii. determine the main effect of gender on Biology students' academic achievement when taught Cell Biology at Federal College of Education in Southwest, Nigeria;
iv. examine the interaction effect of concept mapping strategy and gender on Biology students' academic achievement when taught Cell Biology at the Federal College of Education in Southwest, Nigeria;
v. examine the interaction effect of cooperative learning strategy and gender on Biology students' teachers' academic achievement when taught Cell Biology at the Federal College of Education in Southwest, Nigeria;

1.4 Hypotheses

The following hypothesis were tested in the study at 0.05 level of significant

$H_0$1: There will be no significant main effect of concept mapping strategy on Biology students' academic achievement when taught Cell Biology at Federal College of Education in Southwest, Nigeria.

$H_0$2: There will be no significant main effect of cooperative learning strategy on Biology students' academic achievement when taught Cell Biology at the Federal College of Education in Southwest, Nigeria.

$H_0$3: There will be no significant main effect of gender on Biology students' academic achievement when taught Cell Biology at Federal College of Education in Southwest, Nigeria.

$H_0$4: There will be no significant interactive effect of concept mapping strategy and gender on Biology students' academic achievement when taught Cell Biology at the Federal College of Education in Southwest, Nigeria.

$H_0$5: There will be no significant interactive effect of cooperative learning strategy and gender on Biology students' teachers' academic achievement when taught Cell Biology at the Federal College of Education in Southwest, Nigeria.

1.5 Scope of the Study

This study determine the impact of concept mapping strategy and cooperative learning strategy on the academic achievement of Federal Colleges of Education students in Cell Biology in Southwest, Nigeria. The study was carried out at three Colleges of Education: Federal College of Education (Special) Oyo, Oyo State, Federal College of Education Osiele Abeokuta, Ogun State, and Federal College of Education Iwo, Osun State. This study focused on cell topics within the field of Biology, specifically targeting pre-service teachers enrolled in Biology courses at various Federal Colleges of Education.

1.6 Significance of the Study

The findings from the study are anticipated to significantly enhance the quality of science education across Nigeria. Through the identification of effective teaching strategies, including concept mapping and cooperative learning, Biology students can cultivate a deeper comprehension of scientific concepts, enabling them to convey knowledge more effectively to their future students. This enhancement in instructional strategies could significantly raise the overall quality of science education in the area. The findings of the study would provide important insights into the effectiveness of various teaching strategies used in pre-service teacher training programmes.

Teacher, educators and curriculum developers can use these findings to reevaluate and modify existing teaching/learning. Incorporating innovative strategies like concept mapping and cooperative learning can help align the training programmes with the best practices in pedagogy, fostering well-prepared and competent Biology teachers. Its can serve as a valuable resource for ongoing professional development initiatives for in-service Biology teachers as well. School administrators and educational institutions can use these insights to organise workshops and training sessions, promoting the adoption of concept mapping and cooperative learning strategies among teachers, thus elevating the overall teaching standards in the region.

In addition, the outcomes of the study would address educational issues and promote active teaching. Active teaching is encouraged through the use of concept mapping and cooperative learning strategy which in turn encourages Biology students instructors to engage more actively with the subject matter. These tactics may develop a feeling of ownership and interest in teaching by stimulating critical thinking, problem-solving, and cooperation; eventually, this would lead to a more fun and meaningful teaching experience for both instructors and students. In the field of scientific education, Nigeria, like many other nations, struggles with issues such as low levels of students involvement, high dropout rates, and below-average academic ability. This study has the potential to contribute to the addressing of these difficulties by finding effective teaching practices that can enhance the preparation and competency of pre-service Biology instructors, ultimately leading to improved teaching outcomes for the students who would be taught by these teachers in the future.

In terms of the implications the study has for policy and the contributions it can make to research, the research may be utilised as a foundation for evidence-based policy recommendations in the field of scientific education. The findings may be used by governmental bodies and educational institutions to establish and execute policies that encourage the integration of concept mapping and cooperative learning strategies into teacher training programmes. This would facilitate ongoing enhancement in the calibre of scientific education throughout the region. The results of the study would enhance the current knowledge base regarding innovative teaching strategies, specifically in relation to Biology education in Southwest, Nigeria. It has the potential to stimulate more research and the investigation of successful teaching strategies, not just in Biology but also in other scientific and non-scientific fields of study.

1.7 Limitation of the Study

A major limitation was in the areas of time and controlling of students in school selected by the researcher in the course of carrying out the study.

1.8 Operation Definition of Terms

Terms are defined according to their usage in this study. These terms includes:

Academic Achievement: In Cell Biology , these are scores obtained by Biology students using the instrument, Cell Biology Achievement Test (CBAT) for the study.

Colleges of Education: These are institutions that train pre-service teachers. In this study Part 1 Biology students were considered.

Concept Mapping Strategy: This is a visual and graphical strategy used to represent the relationships between different concepts or ideas in Cell Biology which in this study is the focused topic.

Cooperative learning strategy: This is an educational strategy that emphasises collaborative and interactive teaching among students. In this instructional strategy, pre-service Biology teachers' work together in small groups to achieve common teaching goals on the topic of Cell Biology.

Biology students in Federal College of Education: These are individuals who are currently undergoing formal education to become a qualified teacher but have not yet begun their teaching career.

Gender: These are male and female pre-service Biology teachers' at Federal Colleges of Education in Southwest, Nigeria.

Endnotes

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Chapter Two

Literature Review

The chapter reviewed the related literature on the study under the following sub- headings.

2.1 Conceptual Review

2.1.1 Academic Achievement

2.1.2 Concept Mapping

2.1.3 Cooperative Learning

2.1.4 Gender

2.1.5 Cell Biology

2.2 Theoretical Framework

2.2.1 Ausubel's Meaningful Learning Theory

2.2.2 Constructivism Learning Theory

2.2.3 Vygotsky's Social Development Theory

2.2.4 Social Interdependence Theory

2.3 Review of Empirical Studies

2.3.1 Concept Mapping Strategy and Biology Academic Achievement

2.3.2 Cooperative Learning Strategy and Biology Academic Achievement

2.3.3 Concept Mapping Strategy and Students Gender

2.3.4 Cooperative Learning Strategy and Students Gender

2.4 Conceptual Model

2.5 Summary of Gap in Literature Reviewed

Endnotes

2.1 Conceptual Review

2.1.1 Academic Achievement

Academic achievement in education refers to the outcome of learning and serves as a gauge of how well students, instructors, and educational institutions have accomplished their educational goals. Based on the consistently poor levels of academic achievement in Biology and the negative attitude towards it, it is evident that scientific education has been inadequately implemented. The assessment of academic achievement is typically conducted through examinations or ongoing evaluation, although there is no widespread agreement on the best effective testing strategy or the key components of knowledge. Achievement, in the context of educational environments such as schools, colleges, and universities, refers to the measurable outcomes of a person's achievement that indicate the extent to which they have successfully attained specific objectives[1]. In addition to the problem of low achievement in Biology in educational institutions, it is common for students in Nigerian schools to choose Biology because it is a scientific subject that is relatively easy to earn high grades in, making it particularly appealing to them. Interest is crucial when it comes to teaching and learning Biology. Furthermore, there exists a correlation between student engagement and the instructional strategies utilised by the lecturers. Given this information, a number of scholars suggest implementing innovative strategies to improve students academic achievement[2].

Although numerous novel strategies have been employed, Biology students instructors persist in doing poorly and displaying minimal enthusiasm for the subject. This emphasises the significance of conducting experiments using a teaching strategy and strategy that are compatible, and studying how Concept mapping and cooperative learning might impact the achievement and focus of Biology teachers. Academic achievement refers to the progress and growth of students, which is determined by their learning experiences in an educational programme that is designed to fulfil specific goals and objectives. Academic accomplishment refers to the actual abilities and knowledge that students acquire while participating in an educational programme[3]. In the field of education, academic achievement refers to the amount of knowledge acquired through formal education, and the outcome and impact of instruction received in a learning setting. Colleges achieve their educational aims by assessing learners' progress through grades[4]. The course seeks to modify learners' behaviour by targeting those specific goals. Academic achievement is defined as the acquisition of proficiency in a specific skill or area of knowledge. Academic achievement in educational institutions such as schools, colleges, and universities encompasses a student's achievement in several settings, including classrooms, laboratories, libraries, and work environments[5].

2.1.2 Concept Mapping Strategy

Concept mapping is a teaching technique that was introduced by Joseph D. Novak in 1970 as a way to represent students' understanding of scientific knowledge. Concept mapping serves as an effective learning strategy that numerous students utilise to grasp intricate concepts and elucidate unclear connections. Developing a graphic representation of a topic frequently aids in visualising key concepts and organising knowledge more clearly than other strategys of study. Novak's exploration of concept mapping was grounded in the principles of learning psychology theory. The core principle in cognitive psychology theory is that learning occurs through the integration of new concepts and propositions into the existing conceptual and propositional frameworks possessed by the learner. The implementation of concept mapping as a tool has therefore enhanced meaningful learning in the sciences and various other disciplines, while also serving to illustrate the expert knowledge of individuals and themes across education, government, and business. Concept mapping, as an instructional strategy, encompasses the elements of observation, inference, classification, hierarchical structuring, and construction[6].

In Western countries concept mapping is a widely adopted pedagogical strategy for teaching Biology and other relevant science disciplines and has been documented as a highly effective strategy for facilitating meaningful learning among students by explicitly revealing the connections between scientific topics. Additionally, reports suggest that the use of concept mapping improves students' problem-solving skills and promotes collaborative learning. A concept map serves as a visual representation that illustrates the structured arrangement of ideas within a specific academic discipline, akin to a two-dimensional map that facilitates comprehension, similar to a road map. Concept mapping is a type of graphical tool that is utilised to organise and visually express knowledge. This encompasses abstract notions, typically represented by circular or boxed shapes, and the interconnections between these notions denoted by connecting lines. Linking words or phrases, often known as connectives, indicate the specific relationship between two concepts[7].

A concept map serves as a visual representation designed to depict the connections and relationships among various ideas or terms. It operates in a manner akin to how a sentence diagram illustrates the grammatical framework of a sentence, a roadmap outlines the locations of highways and cities, and a circuit diagram reveals the operation of an electrical device. In essence, it provides a visual representation that outlines the pathways to develop comprehension of concepts and assertions, functioning as both a tool for meta-learning and meta-knowledge. Concept mapping serves as a cognitive tool that improves logical reasoning and academic skills by visually representing the connections between concepts. Students possess the ability to not only perceive connections, but also to mentally represent how complex concepts are deconstructed into more basic components. Concept mapping is designed to depict the patterns of text structure, aiding Students in developing their mental constructs or schemata of text organisation. By employing the technique of mapping, teachers assist Students in visualising linkages and comprehending patterns in text structure[6].

Concept mapping is a visual representation of essential concepts designed to illustrate the significant relationships among the chosen concepts or ideas under investigation. Concept mapping serves as an effective learning strategy that aids students in comprehending intricate concepts and elucidating unclear relationships. Additionally, concept mapping can be viewed as an instructional strategy where ideas encompassing two or more concepts are linked with other terms to create meaningful statements depicted in a diagrammatic form. This can be viewed as a strategy for visually depicting the organisation of information. Concept mapping serves as a tool for organising and representing knowledge, which includes concepts typically enclosed in circles or boxes of various types, along with the relationships between concepts and propositions connecting two concepts. Propositions are assertions regarding certain objects or statements within the universe, whether they arise naturally or are artificially created. Their structure comprises two or more concepts linked by additional words to create a coherent statement. A concept map serves as a graphical representation in which links (points or vertices) denote concepts, while cross links (arcs or lines) illustrate the relationships between these concepts. The relationships among the concepts may be unidirectional, bidirectional, or non-directional. The concepts and their connections can be classified, and the concepts may exhibit temporary or causal relationships with one another. A concept map serves as a visual representation of the connections between a central idea and other knowledge that students have acquired. Concept mapping functions as a means for learners to structure their cognitive frameworks into more effective integrated patterns.[7] Additionally, it acts as a meta-cognitive tool that enables learners to take control of their learning in a significantly meaningful way[8].

The science curriculum emphasizes a paradigm shift from instructional strategies that are teacher-centered (behaviorism) such as lecture strategy to students-centered strategies (constructivism) such as concept mapping[3]. Concept mapping originated with Novak at Cornell University during the early 1970s.[9]. This strategy is rooted in a constructivist learning strategy derived from Ausubel's assimilation theory of cognitive learning, with the goal of promoting meaningful learning among students. Concept Mapping originated from the term "concept map". Concept mapping consists of diagrammatic representations that illustrate meaningful relationships between concepts as propositions linked together by terms, circles, and cross links[5.] Additionally, concept mapping, often referred to as a Knowledge Graph, consists of network nodes (points or vertices) and links (edges or arcs). Each node symbolises a concept, while each connection illustrates the relationship between these concepts.

Concept mapping is the process of seeking out related concepts, ideas and sub-concepts for a particular topic; and linking them up with lines on which are inscribed possible propositions that can define their relation; and laying them out carefully to bring out ones understanding graphically. Concept mapping involves stages and these include; brainstorming stage, organizing stage, laying out stage, linking stage and finalizing the concept and when Students are allowed to actively engage in concept mapping, it enhances their understanding and makes learning more meaningful[9].

Additionally, concept mapping serves as a strategy for visually depicting the organisation of information, concepts, and their interconnections. Studies in the field of science education indicate that concept mapping serves as an effective teaching and learning strategy across all educational levels, from primary school to university. This serves as a resource for significant learning, evaluation, instructional design, and identifying alternative concepts or misconceptions that learners may possess. The use of concept mapping results in a significant enhancement of memory retention, as evidenced by improved outcomes in delayed post-tests when compared to alternative teaching and learning strategies. Concept mapping can be beneficial when used alongside other hands-on learning strategies such as experiments and interactive materials. In a concept map, concepts are depicted as nodes, typically contained within circles or boxes, while the relationships between these concepts are shown through connecting lines that link them together. The designation for the majority of concepts is typically a solitary term, though at times, symbols like + or % may be employed. A fundamental component of a concept map is a proposition, defined as a statement regarding certain objects or events that includes two or more concepts linked by a labelled connection[10].

Concept mapping serves as an effective tool for students to understand their knowledge structure and the process involved in constructing knowledge. In this manner, concept mapping aids students in understanding the process of learning itself (meta-learning). Concept mapping necessitates engagement across all six levels: knowledge, comprehension, application, analysis, evaluation, and creation (synthesis) as outlined in Bloom's educational objectives within the cognitive domain. The conceptual understandings that students attain in a new learning activity are significantly influenced by their prior knowledge. Concept mapping has been utilised to investigate students' prior knowledge, to monitor a student's progression of knowledge throughout a course, to compare students at varying levels of understanding, and so on[11].

Educators and learners frequently find it easier to pinpoint misunderstandings when utilising a Concept Map. "Concept mapping can clarify for students (and the instructor for curriculum development purposes) the limited number of truly important concepts they need to learn." They also indicate that concept mapping externalises an individual's knowledge structure and can highlight any conceptual misconceptions that the individual may possess regarding the knowledge structure. This detailed assessment of understanding and the following identification of misunderstandings enables precise corrective measures. Since concept mapping involves visual images, they are generally more easily remembered than text. Concept mapping has also been utilised to pinpoint specific misconceptions in knowledge and to explore alternative educational strategies to tackle these misconceptions[11,12].

A fundamental aspect of concept mapping is that they are designed to illustrate the structural patterns of texts, aiding students in developing their mental constructs or schemata regarding text organisation. Through the process of mapping ideas into structured models, educators facilitate students' ability to visualise relationships and recognise patterns in text. While concept mapping enhances learning and comprehension, novices often find themselves overwhelmed by the complexities involved in the mapping process. To address the challenges faced by beginners in utilising concept mapping for text-based learning, several training studies have been reviewed[13]. Furthermore, the concept of mapping ideas aims to assess the extent to which meaningful learning enhances student achievement. Concept mapping as an educational strategy aligns with the shift from teacher-centered to learner-centred strategyes, thereby enhancing academic achievement[13]. Today, it is widely accepted that most students learn best through personal experience and by linking new information to their existing beliefs or knowledge. For this reason, individuals must actively build their own understanding[14].

One important aspect underlying concept teaching or learning comes from the field of human development. Research in this field has shown that the process of learning concepts begins at an early age and continues throughout life as people develop more and more complex concepts, both in school and out. Students come into classrooms with a variety of prior experiences from which they have formed conceptions, or schemata, about the physical and social worlds. Sometimes these conceptions are accurate and other times they misrepresent reality. Misconceptions cannot be altered merely by introducing new information. Change necessitates the implementation of instructional strategies that facilitate students' awareness of their current mental frameworks and assist them in cultivating new concepts and reinterpreting established thought patterns. The strategy to teaching concepts is crucial for comprehending these schemata and fostering meaningful learning. It indicates that rote learning takes place when the learner does not attempt to connect new concepts and propositions to the relevant prior knowledge they already have[13,14].

Additionally, concept mapping serves as an effective learning strategy that aids students in grasping intricate concepts and elucidating unclear relationships. A concept map serves as a two-dimensional illustration that depicts the connections among essential ideas[15]. It reveals our cognitive processes and proposes connections and associations that may not be immediately apparent. At first glance, a concept map resembles a flow chart where key terms are positioned in boxes linked by directional arrows. Concept mapping serves as an effective tool that offers educators diagnostic pre-assessment before initiating a unit and facilitates formative assessment throughout learning activities[16].

A concept map is a structured representation consisting of nodes that are interconnected through labelled directed pathways. The interconnected nodes illustrate the manner in which students associate or relate various concepts. The propositions are illustrated through arrows that connect individuals' concepts; the direction of the link is denoted by the arrow. The way students conceptualise the materials is reflected in the directionality and the connecting proposition. The proposition illustrates the contextual relationship among the concepts involved. Concept mapping is grounded in the idea that concepts are interconnected and derive their meaning from their relationships with other concepts. Concept mapping illustrates knowledge in a structured, hierarchical manner. The hierarchical structure serves as a strategy for connecting concepts with one another. The advocates of the concept mapping strategy argue that meaningful learning occurs when a learner is conscious of and can manage the cognitive processes linked to learning. Concept mapping can diminish reliance on rote memorisation and enhance the significance of the learning experience. Consequently, it boosts students' interest and improves problem-solving techniques, regardless of their ability level or gender[16].

Concept mapping serves as a metacognitive learning strategy that assesses an individual's knowledge structure and organisation within a particular domain of knowledge. Meta cognition is defined as "cognition about cognition," "knowing about knowing," or "thinking about thinking." Concept mapping is a strategy employed to illustrate the connections between concepts in a two-dimensional graph. Concept mapping illustrates a network of related concepts, highlighting the defined relationships between pairs of concepts as indicated by the links that connect them[10]. Concept mapping serves as an effective strategy for illustrating concepts within a topic or unit, while also demonstrating their interconnections in a two-dimensional format. The map serves as a valuable tool for both the educator and the student, illustrating their conceptual understanding and the interconnections among various ideas. Concept-mapping serves as an effective instructional strategy that enhances teaching and learning across various subjects. Depending on its intended use, concept mapping has also been referred to as cognitive mapping, mental mapping, concept webbing, concept trees, knowledge mapping, clinical correlation mapping, patterned note taking, and flow charting. These terms all pertain to the concept of visually representing interconnected ideas[16].

Concept mapping offers a visual representation of a specific domain that can help students utilise available materials more effectively. By examining the map, one might discern the essential concepts and organise them from broad to narrow, establishing meaningful connections among them. Consequently, concept mapping serves as an effective yet straightforward strategy for utilising diagrams to represent information in a manner that aligns with one's thought processes. Concept mapping facilitates the comprehension, retention, and communication of intricate information. In this context, the teacher's role has evolved from delivering information to acting as a facilitator[17].

Types of Concept Mapping

Hierarchical Concept Mapping

Hierarchical Concept Mapping is a visual representation and organizational tool used to illustrate relationships and hierarchies among concepts or ideas. It is particularly valuable in educational settings, brainstorming sessions, and knowledge representation. The primary aim of this type of mapping is to showcase the hierarchical structure of various concepts, allowing individuals to understand how these concepts relate to one another in a systematic manner. At its core, Hierarchical Concept Mapping involves arranging concepts in a hierarchical order, with broader or more general concepts placed at the top and more specific or detailed concepts positioned beneath them. This hierarchical structure reflects the natural relationships and dependencies that exist among the concepts. This visual representation aids in comprehending complex topics by breaking them down into manageable and interconnected components[12,14,15].

The mapping process typically starts with a central, overarching concept that serves as the focal point. Subsequently, related concepts are added, forming branches that extend outward from the central point. Each branch represents a category or subcategory, and the mapping continues to expand, creating a tree-like structure that visually organizes the information. The result is a clear and concise depiction of the relationships between different levels of abstraction within a given subject. One of the key advantages of Hierarchical Concept Mapping is its ability to facilitate both top-down and bottom-up learning strategies. Learners can start from the general concepts and progressively delve into more specific details, or they can begin with specific details and trace their way back to the broader concepts. This flexibility in navigation makes the mapping technique adaptable to various learning styles and cognitive preferences. In educational contexts, teachers often use Hierarchical Concept Mapping as a teaching tool to help students grasp complex topics and enhance their understanding of the interconnectedness of ideas[17].

Hierarchical Concept Mapping is not limited to a single format; rather, it can take various visual representations depending on the context and the preferences of the individual or group creating the map. Commonly, hierarchical maps can be structured as tree diagrams, with the central concept as the root and branches extending outward. However, some maps may take on more intricate forms, such as mind maps or concept webs, which allow for more flexible connections between concepts. The adaptability of this mapping technique makes it suitable for a wide range of subjects and disciplines[18].

The process of creating a Hierarchical Concept Map involves careful consideration of the relationships between concepts. Lines or arrows are often used to indicate connections, with labels explaining the nature of the relationship (e.g., "is a part of," "is a type of"). The visual cues provided by these connections aid in reinforcing the understanding of how concepts interrelate.

Additionally, the use of color, symbols, and other visual elements can enhance the clarity and memorability of the map, making it a powerful tool for both teaching and learning. Beyond its applications in education, Hierarchical Concept Mapping is utilized in various fields, including business, project management, and knowledge management. In business, it can help organizations organize and communicate complex ideas or strategies. In project management, it can assist in breaking down large projects into manageable tasks and subtasks. In knowledge management, it aids in structuring information and fostering a better understanding of the relationships between different components within a knowledge domain. In conclusion, Hierarchical Concept Mapping is a versatile and effective tool for visually organizing and representing complex information. Whether used in educational settings or professional environments, its hierarchical structure and visual clarity make it a valuable asset for comprehending, communicating, and managing interconnected concepts and ideas[19,20].

Spider Concept Mapping

Spider Concept Mapping is a visualization technique used to represent relationships and connections among concepts or ideas in a hierarchical and radial fashion. Unlike traditional concept maps that often follow a linear or tree-like structure, Spider Concept Mapping employs a central node from which multiple branches radiate outward, resembling the legs of a spider. This central node typically represents a core or central theme, while the branches symbolize different subtopics or related concepts. In Spider Concept Mapping, the central theme is connected to secondary nodes, which, in turn, branch out to tertiary nodes and so on, forming a web-like structure. Each node represents a specific concept, idea, or keyword, and the lines connecting them illustrate the relationships between these elements. This strategy allows for a more organic representation of interconnected information, providing a comprehensive and visually intuitive overview of a subject[19].

One of the key advantages of Spider Concept Mapping is its flexibility in accommodating complex relationships and interconnectedness. The radial design allows for the inclusion of numerous subtopics without compromising clarity. Additionally, the visual nature of the mapping strategy enhances cognitive understanding, making it a powerful tool for brainstorming, problem-solving, and knowledge representation. Software tools are often employed to create Spider Concept Maps, enabling users to easily manipulate and update the structure as needed. These tools may offer features such as color-coding, different node shapes, and the ability to link multimedia content, enhancing the map's expressiveness. As a result, Spider Concept Mapping proves valuable in educational settings, collaborative projects, and any context where the visualization of interconnected ideas is beneficial. Overall, Spider Concept Mapping provides a dynamic and versatile strategy to concept visualization, fostering a deeper understanding of complex topics. Furthermore, in Spider Concept Mapping, the dynamic and interconnected nature of the visual representation allows for a holistic exploration of a subject. The radial layout encourages non-linear thinking, enabling users to trace relationships between concepts more freely and creatively. This flexibility is particularly advantageous when dealing with multifaceted topics or when trying to capture the complexity of real-world scenarios. The spatial arrangement of nodes and branches fosters a sense of spatial proximity, indicating the strength and nature of connections between different elements[19,20].

Moreover, Spider Concept Mapping is not limited to a specific domain or field; it can be applied across various disciplines, including education, business, science, and more. In educational settings, teachers and students use Spider Concept Maps to organize and synthesize information, making it an effective tool for studying and reviewing complex subjects. In business and project management, Spider Concept Mapping aids in strategic planning, helping teams visualize goals, dependencies, and potential challenges. The collaborative aspect of Spider Concept Mapping is another noteworthy feature. Multiple individuals can contribute to the map simultaneously, either in a physical or digital environment, facilitating group discussions and knowledge sharing. This collaborative strategy promotes a shared understanding of complex concepts among team members and stakeholders[21].

Furthermore, the evolving nature of information can be seamlessly incorporated into Spider Concept Maps. As ideas develop or new connections emerge, the map can be easily updated to reflect the latest insights. This adaptability makes it a valuable tool for dynamic fields where knowledge is continually evolving. Spider Concept Mapping stands out as a versatile and dynamic strategy for visualizing relationships and connections among concepts. Its flexible and collaborative nature, combined with its adaptability to various domains, positions it as a valuable tool for enhancing understanding, fostering creativity, and facilitating effective communication in diverse contexts[20,21].

Flowchart Concept Mapping

Flowchart Concept Mapping is a visual representation technique that utilizes flowchart symbols and structures to illustrate the sequence of steps, processes, or decision-making within a system or concept. Unlike other concept mapping strategys that emphasize hierarchical relationships, flowchart concept mapping focuses on the flow of information, actions, or decisions in a linear fashion. The primary objective is to provide a clear and systematic depiction of how different elements are connected and how they lead to specific outcomes or results. In this mapping strategy, basic flowchart symbols such as rectangles for processes, diamonds for decision points, ovals for start or end points, and arrows for connections are employed to represent various components and their relationships. Each symbol denotes a specific action or decision, and the arrows indicate the direction of the flow. This visual structure makes it easy to follow the logical progression of steps or events, aiding in understanding complex processes and systems[20].

Flowchart Concept Mapping is widely used in business process analysis, system design, programming, and problem-solving. It serves as a powerful tool for breaking down a complex concept into manageable steps, allowing individuals to analyze, optimize, and communicate processes effectively. This mapping technique is particularly beneficial when documenting workflows, designing algorithms, or creating procedural manuals, providing a visual guide that enhances clarity and reduces the likelihood of errors. One notable advantage of Flowchart Concept Mapping is its universality. The standardized symbols make it easy for individuals across different disciplines and industries to understand and interpret the flowchart, promoting clear communication and collaboration. Additionally, software tools are often employed to create digital flowcharts, enabling easy modification and updates as processes evolve or require optimization[20].

Flowchart Concept Mapping is a visual representation strategy that emphasizes the sequential flow of steps, processes, or decisions within a concept or system. Through the use of standardized symbols, it offers a clear and systematic depiction of complex workflows, aiding in analysis, optimization, and communication in diverse fields such as business, programming, and problem-solving. Flowchart Concept Mapping is not only a valuable tool for representing sequential processes but also for identifying decision points and conditions within a system. Decision diamonds in a flowchart allow for branching paths based on different conditions or choices, enabling the depiction of various scenarios and their corresponding outcomes. This feature makes Flowchart Concept Mapping particularly useful for decision-making processes, project planning, and scenario analysis[18].

The modularity and scalability of Flowchart Concept Mapping are additional strengths of this strategy. Large and intricate systems can be broken down into smaller, more manageable components represented by individual flowchart segments. Each segment can then be detailed separately, allowing for a comprehensive understanding of both the overall process and its specific components. This modularity facilitates collaboration, as different team members can focus on specific aspects of the concept or process. Furthermore, the visual nature of Flowchart Concept Mapping aids in the identification of bottlenecks, redundancies, or inefficiencies within a process. By analyzing the flowchart, individuals can pinpoint areas that may require optimization, streamlining, or reengineering. This makes the strategy an essential tool in process improvement initiatives and project management, where efficiency and resource optimization are crucial[18,21].

The adaptability of Flowchart Concept Mapping also extends to its use in educational settings. Teachers and trainers often employ flowcharts to visually explain complex procedures or systems, facilitating Students comprehension through a step-by-step breakdown. In this context, the strategy serves as a pedagogical tool for enhancing learning and retention. Flowchart Concept Mapping is a versatile and widely applicable visualization technique that excels in representing sequential processes, decision points, and conditions within a system. Its modularity, scalability, and adaptability make it a valuable tool for diverse applications, ranging from business and project management to education and process optimization. By providing a visual roadmap of complex concepts, Flowchart Concept Mapping aids in analysis, communication, and improvement across various fields[20].

Features of Concept Mapping

Concept mapping is structured in a hierarchical manner, with the most inclusive and general concepts positioned at the top of the map, while the more specific and less general concepts are organised hierarchically beneath them. The hierarchical structure for a specific area of knowledge is influenced by the context in which that knowledge is applied or evaluated. Additionally, the inclusion of cross links represents the relationships between links across various segments or domains within the concept mapping. Cross links enable us to understand the connections between concepts in different domains of knowledge as represented on the map. The development of new knowledge relies heavily on the importance of cross links in fostering creative thinking. A well-structured map provides a hierarchical framework that enhances the ability to explore and define new connections[15,17].

The concluding aspect involves particular instances of events or objects that aid in elucidating the meaning of a specified concept. Typically, these are excluded from the ovals or boxes, as they pertain to specific events or objects rather than representing broader concepts. Concept mapping illustrates significant connections through propositions that exist between various concepts. Propositions consist of two or more concept labels connected by words that convey information about the relationships or connections between those concepts[18].

Role of Concept Mapping

Concept mapping is characterised as a process that fosters active learning, as it involves learners actively seeking knowledge instead of passively receiving it. Nonetheless, concept maps prove beneficial in various aspects of higher education, such as achieving the overarching objectives of a learning program, refining curriculum design, conducting both qualitative and quantitative studies, improving instructional strategys, and supporting assessment processes[17].

Since concept mapping clearly defines a central idea or theme and indicates the relative importance thereof the concept map allows integrated thinking and portrays information holistically. Bearing this in mind the role of concept maps in each of the aforementioned areas will briefly be touched on. Concept maps create a platform for brainstorming because the structure of a concept mapping provides opportunity for convergent thinking, an integral part of planning processes in higher education. It aids in the pre-arrangements of ideas within specific planning process like curriculum planning, the planning of a learning programme, a module, a learning activity, an assignment or a research project[19,21].

Concept mapping aids in achieving and complying with the overarching educational objectives of learning programs, which aim to facilitate academic success for learners. Additionally, concept mapping serves as a tool to evaluate the effectiveness of learning programs. The condense form of a map can limit the time-imposed constraints of comprehensive documenting and reporting when conducting quality control on academic programmes. In addition, academic programme content or learning area content portrayed in the form of a map, can also indicate gaps or overlaps which is helpful in curriculum planning. To progress towards a resolution during quantitative and qualitative research, concept mapping strategies may also be useful to analyse thinking processes. Concept mappings emphasize and reveal s the interaction and contradiction between different concepts, including ca use-effect, part-whole relationships, hierarchies and cross-links in a logically scientific way[10,12,21].

Characteristics of Concept Mapping

The foundational principle is based on Ausubel's assimilation theory, which demonstrates that effective learning of new knowledge occurs when it is connected to prior existing knowledge. A concept map can be regarded as a strategical tool associated with assimilation theory, illustrating key components of the theory, including subsumption, integrative reconciliation, and progressive differentiation.

Semi-Hierarchical Organization: The fundamental motivation for the hierarchical structure of concepts in a concept map stems from Ausubel's idea of subsumption, where more general, superordinate concepts encompass more specific, detailed concepts. This theoretical concept is organised in a hierarchy, with broader ideas positioned at the top and more specific or detailed concepts arranged below them. In practice, the concepts in a concept map are not arranged in a semi-hierarchical manner. Concept maps facilitate the representation of non-hierarchical relationships or cross-links, along with various other forms of non-hierarchical arrangements[17].

Links: This represents yet another crucial element of a concept map. According to Novak and Gowin (1984), a link phrase is essential for connecting concepts to create meaningful propositions, which serve as fundamental units of knowledge in the context of meaningful learning and Ausubel's assimilation theory. Individuals employing alternative graphing strategys have recommended a restricted set of linking phrases that can be applied universally.

Label: A term for the majority of concepts is a word. It may represent a symbol like + or %. Theory of concept mapping does not limit the labels that may be applied. This provides map creators with enhanced flexibility and accuracy in articulating the connections between concepts.

Definition of Nodes: A key feature of a concept map is its restriction of node content to concepts, facilitating a clearer depiction of the interconnections between those concepts. A variety of mapping systems have been created that allow for the graphical representation of ideas and concepts, such as knowledge mapping, mind mapping, cognitive mapping, and semantic networks. Concept mapping is distinct from other mapping types because of the characteristics mentioned above.

Construction of Concept Mapping

Various strategies can be employed in the development of concept mapping. The choice of strategy is contingent upon the intended purpose of the map's construction. Concept mapping can be created manually or with the help of software that supports specific tasks or general diagramming. It may also be developed by individuals or groups, regardless of whether facilitation is involved. The standard strategies for constructing a concept map encompass a series of steps that include: Clarify the subject matter: A concept map that tries to address multiple questions can be challenging to handle. Determine and enumerate the key or overarching concepts related to the subject; Organise concepts in a hierarchical or morphological manner, starting from the most general and inclusive to the most specific, in a way that promotes a clear representation of subsumption relationships. After identifying and organising the key concept, connections are established to create an initial concept map; Connecting phrases are incorporated to illustrate the relationship between concepts; Once you have constructed the initial concept map, seek out cross-links that connect concepts across various sub-domains within the mapping. Cross links assist in clarifying the interconnections between concepts and allow for a review of the map, enabling any essential adjustments to its structure or content[22].

Uses of Concept Mapping Strategy

Concept mapping strategy has demonstrated its effectiveness in enhancing learning for individuals, facilitating knowledge creation for those in investigative roles, aiding organisational structuring and management for leaders, supporting the writing process for authors, and assisting evaluators in assessing educational outcomes. Concept mapping serves to stimulate idea generation and is thought to enhance creativity. For instance, concept mapping can be utilised as a tool for brainstorming. While frequently tailored and unique, concept mapping serves as an effective tool for conveying intricate concepts[23].

A significant benefit of employing concept mapping is that it offers a visual representation of the concepts being examined, allowing for easy focus and clarity. They can be easily updated whenever needed. The formulation process leads to a solid and clear comprehension of the meanings and relationships between concepts. Consequently, concept mapping transforms learning into an engaging and dynamic process, as opposed to a static experience[16,21].

Concept Mapping used by Teachers: Concept mapping is utilised to elucidate and organise challenging concepts in a structured manner. Concept mapping utilised as advance organisers also offers an initial conceptual framework for subsequent information and learning. Employing concept mapping aids educators in gaining a deeper understanding of essential concepts and the interconnections between them. Educators can effectively communicate a coherent and overarching understanding of the concepts and their connections to learners. Employing concept mapping minimises the chances of educators overlooking or misinterpreting critical concepts. When introducing concepts to learners, educators should avoid requiring them to memorise pre-constructed concept maps. This may simply encourage memorisation, thereby undermining the goal of fostering active and meaningful learning for the learner[20].

Concept Mapping used by Students: Employing concept mapping enhances students' comprehension and retention of knowledge. This facilitates the depiction of the concepts and encapsulates their interconnections. A significant number of students struggle to pinpoint the key concepts within a text, lecture, or other forms of presentation. A significant issue arises from a learning pattern that relies solely on the memorisation of information, without necessitating any evaluation of that information. These students struggle to build robust conceptual and propositional frameworks, resulting in their perception of learning as a confusing array of countless facts, dates, names, equations, or procedural rules to memorise. For these students, the content of various subjects, particularly science, mathematics, and history, often presents as a jumble of information to be memorised, which they typically perceive as tedious. A significant number of individuals believe they are unable to attain expertise in the discipline. When concept mapping is utilised in instructional planning and students are encouraged to create their own concept maps during the learning process, those who have struggled in the past can achieve success in understanding science and other subjects, gaining a sense of mastery over the content. Concept mapping serves as an effective instrument for organising and consolidating students' knowledge base, while also fostering cooperative learning among them[21].

Concept Mapping used as Evaluation Tool: Concept mapping serves as a potent tool, functioning not just for learning but also for evaluation, thereby promoting the adoption of meaningful learning patterns among students. Employing concept mapping can aid educators in assessing the teaching process. They can evaluate student achievement by pinpointing misconceptions and identifying gaps in understanding. Concept mapping serves as an effective tool for evaluating students' understanding and suggests that textbooks could incorporate the use of concept mapping to summarise students' comprehension at the end of units or chapters. They highlighted that “there is nothing set in stone that dictates the use of multiple choice tests from grade schools to the university.” In essence, there is no strict and definitive guideline for educational institutions to exclusively utilise multiple choice or essay assessments for evaluation[17].

Identification of Current Understanding, Misconception and Conceptual change: Concept mapping has been utilised to investigate students' prior knowledge and to monitor a student's progression of knowledge throughout a course, and to compare students at varying levels of understanding and so on. The extent to which students grasp concepts in a new learning activity is significantly influenced by their existing knowledge base. Concept mapping has been utilised to pinpoint specific misconceptions in knowledge and to explore alternative educational strategies to tackle these misunderstandings. Educators and learners frequently find it easier to pinpoint misunderstandings when utilising concept mapping[22].

Concept mappings used for Curriculum Planning: The extensive application of concept mapping in curriculum planning has been proposed. The concept mapping effectively outlines the essential concepts and principles to be taught in a clear and concise manner. Concept mapping is characterised by the organisation of knowledge or ideas from general to specific. When utilising concept maps for curriculum planning, developers should create 'macro mapping' to outline the major concepts intended for the entire course or curriculum. Additionally, 'micro mapping' should be employed to detail the knowledge required for each specific segment of the instructional program[22].

Concept Mapping for Capturing and Archiving Expert Knowledge: The application of concept mapping to capture the implicit knowledge of experts is rapidly expanding. Specialists possess a wealth of knowledge that often eludes clear expression to others. Frequently, specialists emphasise the importance of developing an intuitive understanding of the subject matter at hand. Tacit knowledge is developed through years of experience and is partly derived from activities that engage thinking, feeling, and acting. Knowledge that is not explicitly stated, whether from groups or individuals, can be gathered through three primary strategies: conducting interviews with experts, acquiring information through verbal communication, and gaining insights through observation. These strategies remain widely favoured among numerous cognitive scientists, many of whom lack familiarity with Ausubel's contributions and the epistemological concepts underpinning concept mapping. While Novak and Canas identified the aforementioned strategies as beneficial, there remained a need to develop a more effective strategy to illustrate learners' knowledge and the evolution of that knowledge over time[22].

Benefits of Concept Mapping for Higher Education Learners

Concept mapping as a study technique proves beneficial for learners in higher education, as the complexity of study material increases the necessity to distil and simplify information into a more accessible format for effective learning. Concept mapping serves as a valuable tool for facilitating the learning process and enhancing metacognitive skills among learners. Ineffective learning strategies employed during problem-based learning (PBL) can hinder a learner's capacity to define and address problems effectively. Concept maps facilitate the learning process by enabling individuals to gather knowledge from diverse information sources through the use of key terms and visuals[23].

The ability of concept mapping to unveil a complex structure of ideas or multiple connections between concepts is significant. The visual nature of concept maps enables learners to discern the relationships among key ideas, facilitating the exploration of information from various perspectives and interpretations. Concept mapping effectively organises the learning process, leading to higher-quality outcomes in learning. Concept mapping as an instrument to demonstrate knowledge stimulate learners to become thinkers. Learners find themselves in a position to explore their conception of key ideas and mapping assists them in making significant patterns of their knowledge, it further promotes creative thinking by helping learners to generate idea s, to see logical association and view issues from a holistic perspective[24].

Additional benefit put forward in the literature are that concept mapping can serve as a model to replace or support note-taking and note-making which are time consuming tasks. As a study technique, concept maps provide a revision aid and its unique pattern makes memory and recall easier. During the process of learning mind maps provide a framework from which to structure information that enhances learning and provides opportunities to encourage self-regulation and self-efficacy. Self-regulation and self-efficacy among others are factors associated with academic achievement. Academics success can therefore be placed within reach of higher education learners by nurturing these factors through concept mapping[24].

Concept Mapping Process

The concept mapping strategy involves representing groups of ideas visually, creating a map that offers a geographic representation of the topic at hand. The map is constructed by initially describing or generating ideas and then articulating the interrelationships among them. Advanced statistical strategies involving multiple variables Subsequently, multidimensional scaling and cluster analysis are utilised on this data, with the findings illustrated in a mapped format. The composition of the map, representing the collection of ideas, is wholly shaped by the participant group. The team generates initial concepts, shares insights on the connections between these concepts, analyses the findings, and determines the application of the map[24].

This strategy to concept mapping proves to be effective when a collective seeks to establish a conceptual framework for evaluation or planning purposes. The framework illustrates either the present condition of an issue or a future aspirational state, presented through a series of concept maps that visually convey the collective reasoning of the group. The maps illustrate the collective concepts concerning the subject matter, highlighting the interconnections among these concepts and typically indicating which ones hold greater relevance, significance, or suitability.

Concept mapping proves to be highly effective when engaging established groups of various stakeholders, like multiagency steering committees, in planning and evaluation initiatives. Such groups may include administrators, staff, or board members of an organisation; community leaders or representatives from pertinent constituency groups; scholars or individuals involved in policymaking; funding agents or representatives from oversight bodies; collectives of experts and practitioners in particular fields of study; representatives of relevant client populations; or various combinations of these entities. Concept mapping may be less suitable in environments where hierarchical decision-making is standard or where an organization's planning or evaluation frameworks are already established[22,24].

The concept mapping process is directed by a facilitator, who may be an external consultant or an internal member of the team tasked with the planning or evaluation initiative. The facilitator oversees the process, yet the group solely dictates the content, interpretation, and application of the concept map. The facilitation process can be conducted by an individual or a group and may include participants from both within and outside the organisation[24].

Procedure for Implementing Concept Mapping Strategy in the Classroom When employing the idea mapping strategy in the classroom, the educator must adhere to the following steps:

Step I: For each subject to be instructed, the educator will ascertain a focal query or delineate the principal theme.

Step II: Following the choice of the focal issue or topic, the educator enumerates the most significant or overarching concepts related to that topic.

Utilising Concept Mapping Strategy in the Classroom

When employing the idea mapping strategy in the classroom, the educator must adhere to the following steps:

Step I: The educator will identify a focal question or delineate the important issue for each subject to be taught.

Step II: Following the choice of the focal issue or topic, the educator enumerates the most significant or overarching concepts related to that subject.

Step III: The educator arranges the enumerated notions from the most general and inclusive to the most specialised. This activity promotes the clear depiction of subsumption relationships, namely hierarchical organisation.

Step IV: The educator incorporates linkages to create an initial thought map.

Step V: The educator incorporates connecting language to elucidate the relationships among topics.

Step VI: Following the construction of the first idea map, the educator seeks cross-links that connect concepts across various sections or subdomains within the map. Cross linkages assist the educator in elucidating the interconnections among concepts.

Step VII: The instructor will evaluate the map to implement any requisite modifications in structure or content.[24].

2.1.3 Cooperative Learning

Cooperative learning involves organising small groups to facilitate collaborative efforts among students, enhancing both individual and collective learning outcomes. Significant curiosity exists about the impact of social contact on student accomplishment, with cooperative learning demonstrating efficacy across diverse academic levels and disciplines. Cooperative learning is an instructional strategy in which students collaborate in groups to achieve shared objectives. Unlike the traditional strategy in which pupils operate alone or in competition, cooperative learning fosters mutual assistance and the exchange of ideas among students. It involves the pedagogical use of small groups to facilitate collaborative student engagement, hence enhancing classroom learning and achieving collective educational objectives[25].

Cooperative learning is an instructional strategy that engages students in collaborative group activities, highlighting constructive interaction. This technique involves small teams composed of students with varying levels of ability participating in learning activities to enhance their comprehension of a subject. The involvement of each student in the group and collaboration among members is deemed essential. The pupils get recognition for their personal and collaborative endeavours. The cooperative learning technique fosters listening, involvement, and empathy by assigning each group member a vital role in the academic task. Group members must collaborate as a cohesive unit to achieve a shared objective, with each individual relying on the contributions of others. No student can attain their own objective of mastering the content or achieving a favourable grade without collective collaboration. Collective objectives and personal aspirations enhance and support one another. This collaborative strategy promotes engagement among all students in the class, fostering mutual appreciation as contributors to their shared objective[26].

Moreover, cooperative learning signifies a transition in the educational paradigm from a teacher-centered strategy to a more student-centered one, facilitating small group interactions that foster effective problem-solving among peers. There exists a distinction between merely assigning tasks to a group and organising pupils to collaborate effectively. Forming student groups does not inherently foster a cooperative dynamic; it requires systematic management by an educator. Cooperative learning possesses unique characteristics that differentiate it from other pedagogical strategys. The cooperative learning strategy is grounded in social-constructivist theories of learning. This strategy features a classroom setting defined by collaborative assignments, reward frameworks, and small group activities. It can facilitate the instruction of intricate academic content and assist educators in achieving significant social learning and interpersonal objectives[25,26].

Cooperative learning is a student-centered, instructor-facilitated pedagogical strategy wherein small groups of students are accountable for their own learning and that of their peers. It is a pedagogical strategy in which educators arrange students into small groups that collaborate and assist each other in mastering academic material and achieving a shared objective. The educator regulates and oversees the learning environment, devises educational activities and social interactions, and organises work teams. This technique ensures that every student engages in the team, fostering collaboration among members and promoting a collaborative effort that enhances comprehension of the subject matter. A crucial component of cooperative learning is collaborative teamwork and shared objectives. Cooperative learning may be formal or informal, typically necessitating targeted teacher engagement to enhance student interaction and learning.

In formal cooperative learning, students collaborate over one or more class sessions to accomplish a collective task or assignment. Conversely, in informal cooperative learning, small, temporary, ad-hoc groups of two to four students engage for brief intervals, usually within a single class period, to address questions or respond to prompts from the instructor[27].

Teaching strategies that facilitate collaborative learning among students in small groups are referred to as cooperative learning. Cooperative learning involves youngsters collaborating in structured groups, necessitating mutual cooperation for success. Students collaborate to acquire knowledge and are accountable for both their own learning and that of their peers. Cooperative learning is a technique wherein individuals acquire knowledge collaboratively within a small group, assisting one another. Cooperative learning emphasises collaboration, contrasting with the current educational system that prioritises competition. Cooperation, as a human trait, has historically been perceived as the relative lack of competition. Increased competitiveness inside an individual logically and biologically correlates with diminished collaboration[26].

Basic Elements of Cooperative Learning

Even when they aren't really doing it, many educators think they are incorporating cooperative learning into their lessons. The five pillars of an effective cooperative learning lesson plan must be laid out with precision. Positivity and interdependence are the cornerstones of any cooperative education programme[27]. Students need to internalise the idea that they are interdependent, meaning that they will "sink or swim together" if the group as a whole does well. For instance, in mathematics class, a teacher would hand out a series of problems for the students to solve. Students are grouped into threes. It is the goal of this lesson for students to not only understand the right strategy, but also to correctly answer each story problem. When students work in groups, the teacher fosters positive goal interdependence by having them settle on a solution and a plan before moving on. Assigning responsibilities to each pupil helps to foster positive role interdependence. The group listens as the reader reads out the difficulties. Everyone in the team is able to provide a proper explanation of how to tackle each challenge, thanks to the checker. The facilitator politely invites everyone in the group to speak out and contribute their thoughts and feelings to the conversation[27]. By providing each group with a duplicate of the problem, resource interdependence is established. On separate sheets of scratch paper, each students works on the tasks and then discusses what they've learned. To create positive reward interdependence, at the conclusion of the unit, if all members of each group get over 90% on the exam, the group will be awarded five points. Among all beneficial types of interdependence, goal interdependence is the most essential. A shared aim is the cornerstone of any cooperative learning program.[26, 27].

The second element of a cooperative lesson entails direct, constructive interaction, when students collaborate to support, help, motivate, and enhance each other's learning efforts. Students augment one other's learning by articulating problem-solving strategies, discussing the fundamental nature of the concepts and tactics being learnt, sharing their knowledge, and clarifying the connections between current and previous learning. The teacher is tasked with allocating time, organising seating in a knee-to-knee configuration, and cultivating a supportive atmosphere that facilitates open dialogue and mutual assistance among students in their educational endeavours[27].

As for the third part, holding each student to account, it entails checking in on their progress and giving them input on how they may improve. Members of the group shouldn't depend on others to get things done for them and should be aware of who needs more help to finish the assignment. Giving each student their own test and picking one student's work at random to symbolise the group's overall effort are two typical ways to foster individual accountability[27].

Social skills provide the fourth element of a collaborative lesson. For groups to function effectively, it is essential that students acquire and utilise the requisite skills in leadership, decision-making, trust-building, communication, and conflict management. These competencies must be deliberately and meticulously instructed, akin to academic skills. A considerable proportion of students lack prior experience in collaborative learning settings, leading to a shortfall in vital social skills. During the arithmetic lesson, the instructor emphasises the significance of "ensuring comprehension among all students." The educator delineates the competence as the particular language and associated nonverbal actions that the evaluator should utilise[28].

The sixth element of a collaborative lesson is group processing. At the end of the maths session, the groups assess their performance by answering two questions: (1) What constructive activity did each member make to assist the group, and (2) What action can each member undertake to improve the group's success tomorrow? This technique enables learning groups to focus on group cohesion, promotes the development of social skills, ensures members get feedback on their involvement, and acts as a prompt for students to refine the small group abilities essential for collaborative work. Effective processing necessitates the allocation of sufficient time, the prioritisation of specificity over ambiguity, the use of many forms, the encouragement of student interaction, the promotion of social skills while processing, and the clear communication of the processing objectives. Regularly, each group is required to present a signed overview of their processing[28].

Types of Cooperative Learning Group

There are three basic types of cooperative learning which includes base groups, formal cooperative learning groups and informal cooperative learning groups.

Base or Home Groups

Base groups are enduring collaborative learning teams characterised by consistent membership. Students are selected for base groups to provide a balanced distribution of academic proficiency within the group. These organisations are established to facilitate mutual assistance among members, ensuring collective academic success. For instance, they may collect hand-outs on behalf of an absent group member and provide mutual coaching to prepare for individual assessments. The implementation of base groups personalises the classroom, enhances attendance, and elevates both the quality and quantity of learning. For classrooms with a substantial number of learners, it is advisable to utilise base groups. Base groups ought to be established to remain intact for a minimum duration of one term, with an extension being preferable. The greater the number of learners in a class and the more intricate the subject matter, the more essential it is to establish organised basis groups. The members must exhibit compatibility and provide support[29].

Formal Cooperative Learning Groups

These groups may persist for several minutes to many class sessions to accomplish a certain job or assignment, such as solving a set of problems, finishing a unit of work, producing a report, conducting an experiment, or reading and comprehending a story, play, chapter, or book. The members are meticulously selected for diversity to enhance learning and reduce groupthink[29].

Informal Cooperative Learning Groups

These groups are transient, ad hoc assemblies that endure for a brief duration, often one discussion or class time. Members are frequently selected at random and will rotate periodically. Their objectives are to direct student attention on the content to be acquired, provide an anticipatory mindset and atmosphere favourable to learning, and facilitate the prior organisation of the subject to be addressed in a class session. They can guarantee that learners cognitively engage with the subject presented and offer closure to an instructive session. They may be utilised at any moment, but are particularly advantageous during lectures or direct readings. The duration for which most college students can remain focused during a lecture before losing attention is around 20 to 25 minutes. These groups facilitate the segmentation of the lecture and enable learners to assimilate the topic while engaging in class activities[29].

The Bookend Process involves segmenting the lecture into many mini-lectures and facilitating cooperative learning groups, so reducing lecture duration while augmenting comprehension and fostering interpersonal connections among students. When educating, it is essential to consider the various learning styles and avoid the extremes of entirely eliminating lectures or abandoning group activity[29].

Characteristics of Cooperative Learning Groups

Cooperative learning is a pedagogical strategy that fosters learning via student collaboration rather than competition. It is a technique for efficiently utilising student groups within a classroom setting. Cooperative efforts are only anticipated to be more productive than competitive and individualistic efforts under specific conditions. The prerequisites are: positive interdependence, where individual goal fulfilment depends on the success of all group members; individual accountability; face-to-face interaction among peers; utilisation of pro-social skills; and collective processing of an academic assignment[30].

Positive Interdependence

The first prerequisite for a well-structured cooperative lesson is that students perceive their success as interdependent. In cooperative learning contexts, students bear two responsibilities: to master the taught subject and to facilitate the comprehension of that information among all group members. The precise name for the dual obligation is positive interdependence. Positive interdependence occurs when pupils recognise that their success is contingent upon the success of their peers, necessitating collaboration and coordination to accomplish a job. Positive interdependence fosters an environment where students recognise that their contributions enhance those of their peers, leading to collaborative efforts in small groups aimed at optimising the learning experience for all participants through resource sharing, mutual support, encouragement, and the celebration of collective achievements. When positive interdependence is comprehensively grasped, it asserts that the contributions of each group member are essential and crucial for collective success (i.e., the absence of "free-riders"), and every member possesses a distinct input to the collaborative endeavour due to their resources and/or designated roles and responsibilities[30]. Various strategies exist for establishing good dependency within a learning group, including:

Positive Goal Interdependence: Students believe they can accomplish their learning objectives alone if other group members likewise achieve their own goals. The group is unified by a shared objective, a definitive purpose for being. To foster a sense of collective responsibility among students, the educator must establish a definitive group objective, such as "master the assigned material and ensure that all group members comprehend it." The collective objective must consistently be included into the instruction[30,31].

Positive Reward: Each group member receives an identical reward upon the group's attainment of its objectives. To enhance goal interdependence, educators could consider implementing collective rewards (e.g., if all group members get a score of 90% or above on the test, each individual earns 5 additional points). Occasionally, educators provide pupils a collective score based on the group's total output, an individual grade derived from assessments, and additional points if all group members meet the testing criteria. Frequent recognition of collective achievements improves the quality of collaboration[31].

Positive Resource Interdependence: Each group member possesses just a fraction of the requisite resources, information, or materials essential for job completion; the members must amalgamate their resources to attain the group's objectives. Educators may seek to emphasise collaborative connections by providing students with restricted resources that necessitate sharing (one copy of the issue or work per group) or by distributing portions of the needed materials to each student, which the group must then integrate (the Jigsaw strategy)[31].

Positive Role Interdependence: Each member is designated complementary and interlinked roles that delineate tasks essential for the group to accomplish the collective task. Educators foster role interdependence among students by assigning them complementary responsibilities, including reader, recorder, comprehension verifier, involvement encourager, and knowledge elaborator. Such responsibilities are essential for superior learning outcomes. The checker role, for instance, emphasises routinely prompting each group member to articulate the material being learnt. Additional forms of positive dependency exist. Positive task interdependence occurs when a division of work is established, necessitating the completion of one group member's activities for the subsequent member to fulfil their responsibilities. Positive identity interdependence occurs when a shared identity is formed via a name or motto. Interdependence due to external threats arises when organisations are positioned in competition against one another. Fantasy dependency occurs when a task necessitates that group members envision themselves in a hypothetical scenario[31].

Individual Accountability/Personal Responsibility

Among the first immigrants of Massachusetts, there was a maxim: "If you do not labour, you shall not dine." All individuals were required to contribute equitably to the workload. The second crucial component of cooperative learning is individual accountability, characterised by the assessment of each student's performance, the feedback provided to both the individual and the group, and the expectation that peers hold each other responsible for contributing equitably to the group's success. It is essential for the group to identify those need additional aid, support, and encouragement to complete the job. It is essential for group members to understand that they cannot rely on the efforts of others. When it is challenging to ascertain members' contributions, when contributions are superfluous, and when members are not accountable for the ultimate group result, they may be attempting to exploit the situation. This phenomenon is referred to as social loafing[31].

The objective of cooperative learning groups is to enhance the individual strengths of each member. Personal accountability is essential for guaranteeing that all group members are genuinely enhanced via collaborative learning. Following participation in a collaborative lesson, group members should be more equipped to independently do analogous activities. To guarantee that each student is personally responsible for contributing equitably to the group's tasks, educators must evaluate the effort exerted by each member, offering feedback to both groups and individuals. Students, assist groups in preventing repetitive efforts by members and ensuring that each member is accountable for the final result. Typical strategies for organising individual accountability comprise: Maintaining a compact group size. A lower group size may enhance individual accountability. Administering an individual assessment to each student; Conducting random oral assessments of pupils by selecting an individual to present their group's work to the instructor (in the presence of the group) or to the full class; Monitoring each group and documenting the frequency of contributions made by each member to the group's tasks; Designating one student in each group as the checker. The checker requests that other group members elucidate the reasons and justification for the group's responses; possessing Students impart their acquired knowledge to another individual. When all students engage in this activity, it is referred to as simultaneous explanation. Consequently, a pattern exists in classroom learning. Initially, students acquire information, skills, techniques, or processes inside a collaborative group. Secondly, students independently apply the information or execute the skill, strategy, or process to exhibit their individual mastery of the content. Students collaboratively acquire knowledge and subsequently execute it individually[31].

Face-to-Face Promotive Interaction

Positive interdependence leads to promotive interaction. Promotive interaction is described as individuals supporting and enabling one another's endeavours to accomplish tasks and generate outcomes to attain the group's objectives. While good interdependence may influence outcomes, it is the face-to-face promotive contact among individuals, facilitated by positive interrelationships, psychological adjustment, and social competency, that is crucial. Promotive interaction involves individuals offering each other efficient assistance, exchanging essential resources such as information and materials, and enhancing information processing. It includes providing feedback to improve future performance, challenging each other's conclusions to foster superior decision-making and deeper understanding of issues, encouraging collective effort towards shared objectives, influencing one another's endeavours to attain group goals, acting with trustworthiness, being motivated for mutual gain, and sustaining a moderate level of arousal marked by low anxiety and stress[32].

Interpersonal and Small-Group Skills

The fourth crucial component of cooperative learning is the effective use of interpersonal and small-group skills. To effectively coordinate activities towards shared objectives, students must foster familiarity and trust, communicate clearly and precisely, provide mutual acceptance and support, and address conflicts constructively. Assigning socially inept kids to a group and instructing them to collaborate does not ensure their capacity to do so proficiently. We are not innately equipped with the knowledge to engage effectively with others. Interpersonal and small-group abilities do not spontaneously manifest when required. Students must be instructed in the social skills necessary for effective cooperation and be incentivised to employ them for cooperative groups to achieve productivity. The whole domain of group dynamics is founded on the assertion that social competencies are essential for group productivity[32].

Students with greater social skills and teachers who emphasise the instruction and reinforcement of these qualities might anticipate higher accomplishment in cooperative learning groups. Under the circumstances of cooperative skills training, students received weekly instruction in four social skills, and each member of a cooperative group earned two additional points towards their quiz grade if the teacher witnessed all group members exhibiting three out of four cooperative skills[32].

Group Processing

The fifth crucial element of cooperative learning is group processing. The efficacy of group work is contingent upon the extent to which groups engage in reflective processes on their operational effectiveness. A process is a discernible series of events occurring over time, whereas process objectives pertain to the sequence of events essential for attaining end goals. Group processing is the evaluation of a group session to identify which member behaviours were beneficial or detrimental, and to determine which actions to maintain or modify. The objective of group processing is to elucidate and enhance the efficacy of members in contributing to the collective endeavours aimed at achieving the group's objectives. As the instructor strategically watches the cooperative learning groups, he or she gains insight into students' comprehension as they articulate their understanding of the work to one another. Monitoring the students' explanations yields critical insights into their comprehension of the instructions, key concepts and tactics being taught, and fundamental aspects of cooperative learning[33].

There exist two tiers of processing: small group and full class. To facilitate small-group processing, teachers provide time at the conclusion of each class for cooperative groups to evaluate their collaborative effectiveness. Groups must articulate which member activities facilitated or hindered the completion of their tasks and determine which behaviours to maintain or modify. This processing allows learning groups to prioritise the cultivation of positive interpersonal relationships, enhances the acquisition of collaborative skills, guarantees feedback on individual participation, promotes both metacognitive and cognitive reflection, and offers opportunities to acknowledge group achievements while reinforcing constructive behaviours among members. Key elements for effective small-group processing include allocating adequate time, offering a structured framework (e.g., "Identify three strengths of your group today and one area for improvement."), prioritising positive feedback, ensuring specificity in processing rather than generality, sustaining student engagement, encouraging the application of cooperative skills during processing, and conveying explicit expectations regarding the purpose of the processing[33].

Alongside small-group processing, the instructor should sometimes facilitate whole-class processing. When cooperative learning groups are employed, the instructor monitors the groups, evaluates their collaborative challenges, and provides comments on their teamwork efficacy. The instructor strategyically transitions between groups, observing their activities. A formal observation sheet may be utilised to collect precise data on each group. At the conclusion of the class time, the teacher may facilitate a whole-class processing session by presenting the results of their observations to the class. When each group includes a peer observer, the outcomes of their observations may be aggregated to yield comprehensive class data. A crucial element of both small group and whole-class processing is the celebration of groups and classes. A sense of achievement, appreciation, and respect fosters dedication to study, passion for collaborative work, and self-efficacy about topic knowledge and teamwork with peers[34].

Group Heterogeneity

Cooperative-learning groups are typically small and as diverse as the situation permits. The advised group size typically ranges from four to five students. Groups should, at a minimum, comprise boys and girls, and students of varying skill levels. Representation of many ethnic backgrounds and social strata should be included, if feasible[33].

Purpose of Cooperative Learning

More Students Actively Learning: Co-operative Learning facilitates more student engagement in the learning process compared to teacher-centered or lecture-oriented techniques. Utilising the latter often permits the active engagement of no more than one or two students in active learning simultaneously. Employing cooperative strategies that facilitate group collaboration ensures active engagement of all students in the learning endeavour. Students transform into active participants in their learning, rather than passive users of knowledge who only listen, watch, and take notes[33].

Students acquire the skill of mutual assistance: Co-operative Learning promotes collaboration among students, fostering support for peers within a group rather than competition. Thus, students can amalgamate their abilities and assist one other.

Peer-to-Peer Learning Support: Cooperative learning enables high-achieving students to assist those who study at a slower pace. These high-achieving pupils can likely communicate more effectively with their peers than the instructor can. The assistance of these students also enhances the general level of explanation in the course.

Enhanced Motivation via Achievement: Cooperative Learning enhances student motivation by providing several individuals the chance to experience the satisfaction of victory (particularly in cooperative activities including games) and academic accomplishment. In classes that permit solely individual competition, it is probable that only a select group of high-achieving kids will enjoy this experience. In classrooms where students are organised into cooperative teams comprising both high and low achievers, the chance for success is more equitably spread[33].

Advantages of Cooperative Learning

The benefits of cooperative learning are extensive. Cooperative learning employs both goal interdependence and resource interdependence to facilitate interaction and communication among group members. Transforming the instructor's function from lecturing to fostering group interactions cultivates a social atmosphere conducive to student learning. Cooperative learning fosters amicable relationships among students, enhances social and communication skills, and promotes tolerance and acceptance of difference. It fosters active engagement of students in knowledge production, hence enhancing their interest in the topic. Collaboration in education differs from rivalry. Positive interdependence in cooperation leads to productive interactions where individuals enhance one other's learning endeavours. Conversely, competition, characterised by negative interdependence, typically engenders oppositional interactions, wherein individuals hinder one another's learning efforts, resulting in diminished success and adverse relationships[34].

Cooperative learning aims to provide incentives for groups of students collaborating to accomplish a collective task, in contrast to non-cooperative activities where individuals lack intrinsic motivation to assist their peers in achieving a shared objective. Cooperative learning is beneficial in teaching numerous science disciplines, including Biology, at both secondary and postsecondary educational levels. Cooperative learning is well established in educational research as an effective technique for enhancing students' academic performance. Cooperative learning is predicated on the premise that group members are interconnected, necessitating collective success; they will actively support one another to ensure the completion of the assignment and the attainment of the group's objectives[35].

Furthermore, the potential of cooperative learning is evident to several scholars. The academic and social benefits are well acknowledged; cooperative learning is the acquisition of information within a socially interactive setting by one or two small groups of students. Cooperative learning comprises ideas and practices designed to improve communication among learners for a shared objective. A cooperative learning environment denotes a scenario in which learners, united by a shared objective, endeavour to attain a collective educational aim. A small, devoted cohort of students collaborates, leveraging each other's knowledge to attain a shared objective. In a cooperative learning setting, learners are positioned at the core of the educational process and engage in collective learning. Students will not find learning enjoyable if it occurs in isolation. Consequently, students enhance their critical thinking and cognitive abilities through mutual learning[35].

There are five essential value-added concepts of cooperative learning. Firstly, interdependency among learners facilitates collective learning, since they collaborate in small groups to achieve a common goal. This form of learning holds significant significance for everyone. They mutually gain from each other's expertise. Secondly, every group member is responsible for disseminating his or her information to the others. Thirdly, use their collaborative abilities to assist one another in learning and to motivate participation in problem-solving and cooperative learning. Consequently, they endeavour to enhance the collective accomplishments of the group. Fourthly, equitable opportunities for all; each team member are accountable for participating in the group-building activity and endeavours for its joint success. Fifthly, they collectively engage in learning, interaction, and knowledge transmission. In cooperative learning, students collaborate to achieve shared goals and objectives. All efforts are directed towards a singular objective: to mutually benefit one another via the exchange of personal knowledge and abilities[35,36].

Conversely, cooperative learning utilising computer-mediated technologies enhances the efficiency and enjoyment of group learning. Technology may be included into the cooperative learning environment and can facilitate the attainment of a shared objective among group learners. An educator, in the role of an observer, can provide support as required. These group learners are long-term collaborators who engage in cooperative learning within the classroom and will maintain their collaboration beyond the class. In collaborative environments, small groups of students engage in a designated task to overcome their collective deficiencies, enhance their strengths, and exchange experiences to acquire information. In a collaborative setting, there exists a principle of disseminating information and authority between students and educators[37].

A cooperative setting is a non-threatening learning space where students interact freely without racial prejudice, sharing and exchanging valuable ideas. This situation relies on mutual support, respect for one another, and the reciprocal benefit derived from a collegial and professional relationship. The foundational principle of cooperative learning is the respect for students, irrespective of their ethnic, intellectual, educational, or social origins, and a conviction in their capacity for academic success. All students must engage in surroundings that acknowledge their unique talents and cater to their distinct needs. All children must study inside a nurturing group to feel secure enough to take chances[36].

Collaborative learning fosters a collective feeling of belonging. Acquisition of knowledge, much like existence, is fundamentally a collective endeavour. This strategy provides learners with assistance and motivation via structured classroom engagements. Collaborative dynamic forms, often leading to constructive connections. Cooperative learning holds great potential; it aims to foster active and constructive engagement among students in their learning process. In a collaborative environment, the function of the educator shifts significantly. They do not function as the only source of knowledge, but rather as a companion and a support during times of need. They support learners in nurturing and developing their innovative ideas and constructive thoughts[37].

The effectiveness of cooperative learning relies on the nature of the discussions that occur among students within the group. Discussing a question fosters meaning and comprehension; individuals derive meaning from their experiences through conversation. Research indicates that explaining answers to peers can significantly improve students' comprehension, as the process of clarification and communication deepens their understanding. The focus of these discussions lies in the process itself rather than the correctness of the answers provided. In cooperative learning activities, every team member holds the responsibility of not only grasping the material presented but also assisting their peers in understanding it, fostering an environment of collective success. Students collaborate on the assignment until every group member comprehensively grasps and finishes it[37].

Disadvantages of Cooperative Learning

Cooperative learning consists of groups of three or more students engaging collaboratively to accomplish a task or project. Nonetheless, collaborative learning may face various drawbacks that include but are not restricted to:

Challenges in Group Dynamics: A significant challenge of cooperative learning lies in its dependence on a positive group dynamic to operate at optimal efficiency. Disagreements among individuals can hinder or impede a group's collaborative efforts, presenting a notable challenge when members lack fully developed skills for resolving conflicts. Relationships among students frequently involve playground drama that reflects immaturity. Students are not permitted to exit the classroom. Incompatible personalities can lead to ineffective collaborative learning, even in the absence of conflict or drama. This occurs when students with assertive traits assume leadership positions, regardless of their suitability for guiding the specific project[36].

Imbalanced Workloads and Assessments: Apart from interpersonal disagreements, collaborative learning may lead to a disproportionate allocation of tasks. At its finest, collaborative learning fosters an environment where students uplift and motivate each other, leading to a shared and balanced advancement in understanding. In certain cases, it is observed that more advanced students dominate the project, prioritising convenience and efficiency over the opportunity to assist their peers in the learning process. On the other hand, less motivated students may intentionally depend on their more hard-working peers to finish the tasks, thereby evading any personal effort. The outcome in both scenarios is characterised by an imbalanced workload, which consequently results in disparities in learning, potentially causing some students to lag behind. Similarly, this applies to student evaluations, as it is frequently challenging to assess group members on an individual basis. This may lead to all participants obtaining identical grades or credits, irrespective of their individual contributions[36].

Classroom Management Challenges: Although numerous drawbacks of cooperative learning impact students, this strategy can also present challenges for educators. Collaboration among students necessitates communication between them. Any educator who has overseen a classroom of 20 to 30 students understands that children granted the opportunity to engage in conversation tend to raise their voices, which can disrupt the learning environment. It is also unfeasible for a single educator to consistently oversee every group, which may lead to discussions that stray from the main topic. Collaborative groups of students may also rise from their seats to collectively examine materials. In the absence of stringent discipline, cooperative learning has the potential to transform a well-structured classroom into complete disorder[36].

Relationship between Concept Mapping and Cooperative learning Strategies to the Achievement of Biology Students

Enhanced Understanding and Retention: Concept mapping is a visual learning tool that encourages individuals to organize and represent knowledge in a graphical format. When applied to Biology students, this technique allows them to create visual representations of complex biological concepts, fostering a deeper understanding of the subject matter. The act of constructing concept maps requires active engagement with the material, promoting cognitive processing and knowledge integration. Cooperative learning strategies, on the other hand, involve collaborative learning experiences where pre-service teacher work together to achieve common academic goals. Through group discussions, joint problem-solving, and peer teaching, individuals can gain diverse perspectives and reinforce their understanding of biological concepts. The connection lies in the notion that both concept mapping and cooperative learning enhance comprehension and retention of biological knowledge among Biology students[37,38].

Promotion of Critical Thinking and Problem-Solving Skills: Concept mapping and cooperative learning strategies contribute to the development of critical thinking and problem-solving skills, essential attributes for effective Biology educators. Concept maps require individuals to identify relationships between different concepts and articulate these connections. This process not only aids in understanding but also cultivates analytical thinking. Similarly, cooperative learning strategies, such as group discussions and collaborative projects, expose pre service teacher to various problem-solving strategies. Engaging with peers allows them to confront different perspectives and challenges, fostering the ability to think critically and apply their knowledge in novel situation skills crucial for successful Biology instruction[38].

Building a Supportive Learning Community: Cooperative learning strategies inherently involve building a supportive learning community within a group of Biology students. This sense of community fosters an environment where individuals feel comfortable seeking help, sharing ideas, and collaborating on learning tasks. This support network is invaluable for Biology students facing the challenges of understanding complex biological concepts. Concept mapping, when integrated into cooperative settings, becomes a collaborative endeavor, further strengthening the sense of community. This interconnectedness creates a positive learning environment that encourages active participation and, consequently, contributes to the academic achievement of Biology students[38].

Application of Constructivist Learning Theory: Both concept mapping and cooperative learning strategies align with the principles of constructivist learning theory. Constructivism posits that individuals actively construct their knowledge by building upon their prior experiences and interacting with new information. Concept mapping allows Biology students to organize their existing knowledge and connect it to new biological concepts, facilitating the construction of a more robust mental framework. Cooperative learning, rooted in collaborative learning, aligns with the social aspect of constructivism. Through interactions with peers, Biology students share their interpretations, refine their understanding, and collectively construct knowledge. The synergy between these strategies and constructivist principles establishes a pedagogical foundation that supports the academic achievement of students in Biology[38].

Preparation for Effective Teaching Practices: The connection between concept mapping, cooperative learning strategies, and the achievement of students in Biology extends beyond academic achievement. These strategies contribute to the development of teaching skills and strategyologies. As Biology students engage in creating concept maps and collaborating with peers, they are not only mastering content but also honing skills applicable to future teaching roles. The ability to convey complex biological concepts visually and facilitate collaborative learning experiences prepares them for employing similar techniques in their own classrooms. Ultimately, the integration of concept mapping and cooperative learning strategies equips Biology students with a pedagogical toolkit that enhances their readiness and effectiveness as future Biology educators[38].

Fostering Communication and Interpersonal Skills: Concept mapping and cooperative learning strategies inherently involve communication and interpersonal skills, which are crucial for effective teaching. Constructing concept maps requires pre-service teacher to articulate their thoughts clearly and concisely. Moreover, in cooperative learning settings, individuals engage in active communication with their peers to convey ideas, provide explanations, and collaborate on learning tasks. The development of these communication skills is not only beneficial for the academic environment but also essential for future interactions with Students. The ability to convey complex biological concepts with clarity and engage in effective communication contributes to the overall success of Biology students in their teaching roles[38].

Addressing Diverse Learning Styles: One of the strengths of concept mapping and cooperative learning strategies lies in their flexibility to cater to diverse learning styles. Concept mapping allows Biology students to create visual representations, appealing to those who are visual learners. On the other hand, cooperative learning strategies provide opportunities for different learning preferences by incorporating discussions, hands-on activities, and group projects. Recognizing and accommodating diverse learning styles among Biology students ensures that a broader spectrum of individuals can engage with and benefit from these instructional strategies, ultimately enhancing their academic achievement in Biology[38].

Motivation and Engagement: The incorporation of concept mapping and cooperative learning strategies can contribute to increased motivation and engagement among Biology students. The visual nature of concept maps makes the learning process more interactive and personally meaningful. When pre-service teacher find relevance and personal connections to the material, their motivation to learn is likely to increase. Additionally, cooperative learning strategies introduce an element of social interaction and shared responsibility, making the learning experience more engaging. Higher motivation and engagement levels can positively impact the overall academic achievement of Biology students by fostering a positive attitude towards the subject matter[38].

Assessment and Feedback Integration: The use of concept mapping and cooperative learning strategies allows for innovative assessment strategies and constructive feedback. Concept maps can serve as not only a learning tool but also as a means of assessing the depth and accuracy of understanding. Peer assessments within cooperative learning settings provide Biology students with diverse perspectives on their strengths and areas for improvement. Integrating assessment and feedback into the learning process contributes to a formative strategy, where pre Biology students can continually refine their understanding and teaching skills. This iterative process is conducive to long-term academic achievement and the cultivation of effective teaching practices[39].

Long-term Professional Development: Beyond immediate academic achievement, the connection between concept mapping, cooperative learning strategies, and students in Biology extends to long-term professional development. The skills acquired through these strategies critical thinking, communication, collaboration, and effective teaching strategies are not only relevant during pre-service education but also form a foundation for continuous professional growth. As these future educators transition into their teaching careers, the experiences and skills gained through concept mapping and cooperative learning will contribute to their effectiveness as lifelong learners and educators, positively impacting both their teaching practices and the learning experiences of their students[40].

2.1. 4 Concept of Gender

Gender plays a crucial role in the assessment of Biology students, significantly influencing the attainment of Biology knowledge. The variable of gender is believed to affect students' learning and may also shape their attitudes towards science, particularly in the field of Biology. The concept of gender has attracted the focus of academic professionals in Nigeria, especially in light of the ongoing emphasis on achieving gender equality across multiple sectors. Gender encompasses a range of physical, biological, mental, and behavioural characteristics that differentiate between female and male populations. Gender involves the societal and cultural expectations, characteristics, actions, and rules that are attributed to individuals according to their biological sex. In this study, gender is defined as a characteristic assigned to individuals as either male or female, primarily based on biological characteristics. Challenges associated with gender in science education have emerged as a prominent issue for educators in the field, highlighted by the comprehensive studies undertaken on this matter. Nonetheless, there remains a lack of consensus on whether it influences students in the area of Biology[41].

Nevertheless, several researchers have shown that female students exhibit greater enthusiasm for Biology and chemistry compared to their male peers. Conversely, other studies have found no notable disparity in the average scores of male and female students in science disciplines. These inconclusive findings on gender necessitate additional inquiry to determine whether gender has an impact on pre-service instructors in the field of Biology. The ambiguity over the degree to which gender seems unresolved. Studies have indicated that girls exhibit a more favourable disposition towards Biology compared to guys. Students are the future leaders of education. No research has been conducted on the gender disparity in Biology achievement among students in the south west region. Science serves as a means for fostering economic development and ensuring the survival of every nation. Biology is a widely favoured subject among secondary or students due to its relevance and practicality in addressing the needs of the majority. The inclusion of equity is also considered at this level[42].

Consequently, it provides a robust basis for addressing gender biases and misunderstandings within the realm of science. Investigations into gender disparities in academic performance within the sciences have produced varied findings, indicating that gender could indeed influence students' success in scientific disciplines. Additionally, it was revealed that gender did not play a significant role and had a minimal impact on individuals' success in the domains of science, technology, and mathematics. Nonetheless, the investigation has brought to light worries and unease regarding the insufficient support for female success and accomplishments in the domains of science, technology, and mathematics[43].

Additionally, the investigation into the effects of practical activities in Biology on students' acquisition of process skills reveals that there was no significant difference in the average scores between male and female students who were instructed in Biology through the practical strategy. The findings also indicated an interaction between the teaching technique and gender. A study investigating the effects of a practical assisted instructional technique on student performance in Biology revealed that there was no statistically significant difference in the average Biology achievement scores between male and female students who participated in the activity-based strategy. A subsequent investigation examined the differences in academic performance between male and female senior secondary students who were instructed in ecology through outdoor teaching strategys. It was found that there was no discrepancy in the academic achievement of male and female students who were exposed to indoor and outdoor laboratory instructional tactics. This indicates that both instructional strategies are equally appropriate for all genders[44].

Thus, the impact of gender on pre-service Biology instructors' attitudes towards Biology remains uncertain. This condition highlights the importance of doing this study to investigate any gender disparity among pre-service Biology teachers in their attitudes towards Biology while utilising Concept mapping and cooperative learning as teaching strategies. A recent study has demonstrated that the impacts of concept mapping and cooperative learning are not influenced by gender. Nevertheless, a comprehensive analysis of scientific literature on gender disparities in science accomplishment has revealed a report indicating that male students outperform their female counterparts[45].

The significant disparities in scientific achievement between male and female students have been significantly diminished over time. However, there is still much work to be done in order to fully eliminate this gap. Moreover, other factors have been attributed to this disparity, one of which being the improper utilisation of instructional strategies. Reports indicate that employing concept-mapping as an instructional tool effectively elucidates science topics for students, facilitating meaningful learning outcomes. Furthermore, it has been proposed that differences in gender influence the application of concept mapping and collaborative learning among students studying science, particularly in Biology. The existence of contradictory results regarding student achievement has prompted an exploration into the effects of Concept Mapping and Cooperative Learning strategies on Biology students, along with the implications related to gender[45].

2.1.5 Concept of Cell Biology

Cell Biology, usually referred to as cellular Biology or cytology, is a field of Biology that specifically examines cells, including their composition, activities, and relationships with the surrounding environment. Cells are the fundamental building blocks of all living beings, encompassing both simple single-celled animals such as bacteria and intricate multi-celled organisms like humans. Comprehending the fundamental processes of life, such as growth, reproduction, metabolism, and adaptation, requires a crucial understanding of Cell Biology. The study of cellular structure is essential to the field of Cell Biology. Cells exhibit diverse morphologies and dimensions, with each cell type specialised to carry out distinct physiological roles inside an organism. Cells consist of various organelles, including the nucleus, mitochondria, endoplasmic reticulum, and Golgi apparatus. These organelles collaborate to uphold the cell's structure and perform vital functions such as generating energy, synthesising proteins, and facilitating cellular communication[46].

From a functional standpoint, cells demonstrate extraordinary intricacy and specialisation. They possess the ability to execute a diverse range of functions, such as absorbing nutrients, eliminating waste, moving, and reacting to external stimuli. Cell Biology explores the regulation and coordination of these tasks, frequently through complex signalling channels and molecular interactions. Cell signalling pathways enable cellular communication and response to environmental changes, ensuring coordination and homeostasis in multicellular organisms. Furthermore, the field of Cell Biology is crucial in comprehending the mechanisms of disease and creating effective treatments. Various diseases, including cancer, neurological disorders, and infectious diseases, are characterised by abnormalities in cellular function or structure. Through the process of clarifying the fundamental biological pathways, scientists are able to pinpoint possible areas for drug development and create plans for diagnosis and treatment. Furthermore, strategys such as cell culture, microscopy, and molecular Biology empower scientists to alter and examine cells in controlled laboratory environments, enhancing our understanding of cellular Biology and its practical implications in the fields of medicine and industry [46,47].

The dynamic nature of cells is one of the intriguing elements of Cell Biology. Cells are dynamic entities that experience ongoing processes of proliferation, mitosis, specialisation, and apoptosis throughout their lives. Cell division is crucial for the growth and development of multicellular organisms, and for tissue repair and regeneration. The cell cycle, consisting of interphase, mitosis, and cytokinesis, controls the organised advancement of cell division, guaranteeing precise duplication of genetic material and distribution of cellular components to offspring cells. In addition, Cell Biology investigates the molecular mechanisms that underlie cellular functions. Biological molecules, including DNA, RNA, proteins, lipids, and carbohydrates, interact within cells to perform a wide range of functions through complex networks. For instance, DNA replication and transcription are vital processes that guarantee the accurate transmission of genetic information from one generation to the succeeding one. Protein synthesis, which includes transcription and translation, is crucial for creating the necessary structural and functional proteins that are vital for cellular functions and the overall functioning of organisms[47].

Cell Biology is a multidisciplinary field that includes multiple sub-disciplines dedicated to studying distinct aspects of cellular structure, function, and organisation. The sub-disciplines encompassed in this field are molecular Biology, developmental Biology, structural Biology, and systems Biology. Each of these sub-disciplines provides distinct perspectives on the intricacies of cellular life. Molecular Biology is the study of the molecular mechanisms that drive cellular processes, with a focus on understanding the structure and function of biomolecules such DNA, RNA, proteins, and lipids. The objective is to comprehend the mechanisms by which these molecules interact and control the expression of genes, the creation of proteins, and the transmission of signals inside cells. Strategies such as DNA sequencing, polymerase chain reaction (PCR), and recombinant DNA technologies are essential in molecular Biology research, allowing scientists to manipulate and examine cellular components at the molecular level[47].

Developmental Biology is concerned with the mechanisms through which organisms progress and mature, starting from a single cell and culminating in a sophisticated multicellular organism. This study delves into the cellular and molecular mechanisms that regulate embryonic development, tissue specialisation, and organ formation, and the external influences that impact these processes. Developmental biologists study topics concerning the determination of cell fate, specification of cell lineage, and motions involved in shaping the body using model organisms including fruit flies, zebra fish, and mice. They employ advanced imaging techniques and genetic tools in their research. Structural Biology is the study of the three-dimensional arrangement of molecules and large complexes in cells, with the goal of understanding their activities and how they interact with one other. Strategies like as X-ray crystallography, nuclear magnetic resonance (NMR) spectroscopy, and cryo-electron microscopy (cryo-EM) are employed to ascertain precise structures of proteins, nucleic acids, and other biological components. Structural biologists examine these structures to acquire understanding of the molecular mechanisms that underlie biological functions, such as enzyme catalysis, membrane transport, and signal transduction[48].

Systems Biology employs a comprehensive strategy to investigate biological systems, combining experimental data with computational models to comprehend the interactions between cellular components that give rise to emergent traits and behaviours. Systems Biology utilises strategies from mathematics, computer science, and engineering to scrutinise intricate biological networks, including metabolic pathways, gene regulatory networks, and protein-protein interactions. Systems biologists seek to understand the fundamental principles that govern the behaviour of cells and predict how disruptions to these networks can cause diseases or be used for therapeutic purposes. Cell Biology not only examines individual cells but also explores the organisation of cells into tissues, organs, and organ systems to create intricate organisms. Cell-cell interactions and cell-extracellular matrix interactions are essential for tissue formation, homeostasis, and function. Cell adhesion molecules have a role in cell-cell adhesion and cell-matrix adhesion, which are important for maintaining tissue integrity, facilitating embryonic development, and promoting wound healing. Furthermore, progress in the study of Cell Biology has resulted in the development of disciplines such as stem Cell Biology and regenerative medicine. Stem cells are a type of cells that have not yet developed into specific cell types and have the ability to reproduce themselves and transform into specialised cells. Comprehending the molecular mechanisms that control the choices of stem cells and the regeneration of tissues has the potential to create new treatments for various diseases and traumas, such as spinal cord injury, heart disease, and degenerative disorders[48].

2.2 Theoretical Framework

2.2.1 Ausubel's Meaningful Learning Theory

David Paul Ausubel was an American psychologist known for his substantial contributions to educational psychology, cognitive science, and science education. Ausubel drew inspiration from the teachings of Jean Piaget. In a manner akin to Piaget's notions of conceptual schemes, Ausubel connected this to his elucidation of the process through which individuals acquire knowledge. Ausubel posited that the comprehension of concepts, principles, and ideas is attained via deductive reasoning. In a similar vein, he held a strong conviction regarding the importance of meaningful learning rather than mere rote memorisation. The primary determinant affecting learning is the existing knowledge of the learner. This prompted Ausubel to formulate a compelling theory regarding meaningful learning and the concept of advance organisers[49].

Ausubel posits that the acquisition of new knowledge is contingent upon existing knowledge. The construction of knowledge initiates with our observation and acknowledgement of events and objects, utilising the concepts we already possess. Knowledge is acquired through the development of a web of ideas, which we continuously expand. David Ausubel emphasises that meaningful learning is an essential form of learning for effective classroom instruction. Meaningful learning encompasses new knowledge that connects with the learner's existing understanding, facilitating retention and practical application. Ausubel's theory highlights the importance of students' prior knowledge for achieving meaningful learning. Additionally, educators must recognise the existing knowledge of their students to effectively integrate it into their instructional strategies[50].

Ausubel also stresses the importance of reception rather than discovery learning, and meaningful rather than rote learning. He declares that his theory applies only to reception learning in school settings. He didn't say, however, that discovery learning doesn't work; but rather that it was not efficient. In other words, Ausubel believed that understanding concepts, principles, and ideas are achieved through deductive reasoning. He also suggests the use of an advanced organizer as a way to help students make connections to their ideas with new concepts. this advanced organizer is a device or a mental learning aid to help students get a grip on the new information. The advance organizers can be verbal phrases or graphs[51].

Ausubel aims to facilitate the assimilation and accommodation of new information for students during the learning process; this process must be crafted by the educator to effectively introduce new concepts. David Ausubel emphasises the necessity for students to engage actively, while educators should enhance new learning through techniques such as highlighting, filling in gaps, restructuring sentences, or providing supplementary examples. Ausubel's Theory consists of three essential requirements, which include:

Applicable previous understanding: Students develop cognitive representations of the language that facilitate their connection to new information. Students can critically examine the concepts they encounter at various stages of their second language acquisition in a meaningful manner[52].

Substantial content: In other words, learners develop important ideas and statements that must be pertinent to the knowledge being acquired.

The individual must opt for meaningful learning: Students need to intentionally and thoughtfully connect new information to what they already understand in a meaningful manner[52].

Meaningful Learning

Ausebel's theory emphasises the importance of meaningful learning. His theory posits that for meaningful learning to occur, individuals need to connect new knowledge with relevant concepts they already possess. New knowledge should engage with the existing framework of the learner's understanding. Meaningful learning stands in contrast to rote learning. He advocated for the concept of meaningful learning rather than mere rote memorisation. The latter has the capacity to integrate new information into the established knowledge framework, albeit without any interaction. Rote memory serves to retrieve sequences of items, like phone numbers. Nonetheless, it does not aid the learner in comprehending the connections among the objects.

Meaningful learning entails recognising the connections between concepts, allowing it to be effectively transferred to long-term memory. The integration of new information into existing knowledge structures is the most critical aspect of meaningful learning. Ausubel posits that knowledge is structured in a hierarchical manner, suggesting that new information gains significance when it can be connected to existing knowledge[52].

Requirements for Meaningful Learning

Advance organisers are proposed by Ausubel as a tool to connect new learning material with pre-existing related concepts. Advance organisers facilitate the learning process by aiding comprehension when challenging and intricate materials are presented. This is fulfilled through two criteria: The students are required to analyse and comprehend the information provided in the organizer—this enhances the overall efficacy of the organiser. Additionally, the organiser should clearly demonstrate the connections between the fundamental concepts and terms that will be utilised. Ausubel's theory of advance organisers is categorised into two distinct types: analytical and informative[52].

Comparative organisers serve to activate existing schemas and act as reminders, helping to bring into working memory elements that may not be immediately recognised as relevant. A comparative organiser serves the dual purpose of integration and discrimination. It combines new ideas with fundamentally similar concepts within cognitive frameworks, while also enhancing the ability to distinguish between new and existing ideas that, although fundamentally different, may be easily confused[52].

Expository organisers offer essential new knowledge that students require to comprehend the forthcoming information. Expository organisers serve a crucial role when the learner encounters new and unfamiliar material. Their strategy frequently connects the learner's existing knowledge with new and unfamiliar content, which is intended to enhance the plausibility of the unfamiliar material for the learner.

Types of Meaningful Learning

Representation learning: It is when students acquire vocabulary. In this way, students learn words that represent real objects which have meaning for them; however, it does not identify categories.

Concept learning: It is defined as objects, events, and situations that possess common attributes that are designated through some sign or symbol.

Proposition learning: When students know the concept meaning, they can form structures that contain two or more concepts which affirm or deny something. Thus, a new concept is similar to a structure when it is integrated into new learning with prior ideas that the learner knows.

Ausubel Learning Model

Ausubel believed that learning proceeds in a top-down or deductive manner. Ausubel's theory consists of three phases. The main elements of ausubel teaching strategy are shown below in the table

Table 2.2.1 Ausubel's Model of Meaningful Learning

Phase One :Advance Organizer	**Pharse two** :Presentation of Learning task or Material	**Phase three:** Strengthening Cognitive Organization
Clarify aim of the lesson	Make the organization of the new material explicit	Relate new information to advance organizer
Present the lesson	Make logical order of learning material explicit	Promote active reception learning.
Relate organizer to Students prior	Present material in terms of basic	

knowledge	similarities and differences by using examples, and engage Students in meaningful learning activities	

Source: Ausubel’s Model, 2021

Relevant of Ausubel's Meaningful Learning Theory of Concept Mapping Teaching strategies on student’s achievement in Biology

Ausubel's Meaningful Learning Theory holds significant relevance to the investigation of concept mapping teaching strategies and their effects on the academic performance of Biology students, especially in relation to the topic of the cell. Ausubel posits that meaningful learning takes place when new information is linked to the cognitive structures or concepts that an individual already possesses in their mind. In the realm of Biology education, the concept mapping strategy effectively supports this theory by prompting students to structure and relate their understanding of Cell Biology in a coherent manner.

Concept mapping allows students to visually represent relationships between different components of the cell, fostering a deeper understanding. Ausubel emphasizes the importance of building upon prior knowledge, and concept mapping serves as a tool for activating and reinforcing the relevant existing cognitive structures. By engaging in the process of creating concept maps, students actively construct their understanding of Cell Biology concepts, making the learning experience more meaningful and enduring.

Furthermore, Ausubel's theory highlights the significance of the organization of knowledge in the learning process. Concept mapping aids in the organization of information about Cell Biology, helping students to see the hierarchical structure of concepts within the topic. This organized representation supports the integration of new information into existing cognitive frameworks, contributing to a more coherent understanding of the complexities of Cell Biology. Ausubel's emphasis on advance organizers is also pertinent to this research. Concept maps can serve as effective advance organizers by providing a visual overview of the key concepts and their interconnections before delving into specific details. This strategy can enhance students ability to grasp the overall structure of Cell Biology, facilitating a smoother and more comprehensive learning experience.

Moreover, Ausubel's theory underscores the importance of anchoring new knowledge in the learner's existing cognitive structure. The concept mapping strategy encourages students to relate new information about Cell Biology to what they already know, facilitating a more seamless integration of knowledge. This process not only aids comprehension but also contributes to long-term retention, as the interconnected nature of concepts promotes a robust understanding of the subject matter.

Ausubel's concept of subsumption is particularly relevant when considering the complexity of Cell Biology. The intricate details of cellular structures and processes can be overwhelming, but concept mapping allows students to subsume specific details under broader categories. This hierarchical organization aligns with Ausubel's view that meaningful learning involves fitting new information into a cognitive structure, promoting a more nuanced understanding of the relationships between different aspects of Cell Biology.

Moreover, Ausubel's emphasis on the significance of meaningful reception learning aligns well with the concept mapping strategy. The visual representation of concepts through mapping actively engages educators in the learning process, transcending mere rote memorisation. While developing and enhancing their concept maps, individuals are engaged in the active construction of their understanding of Cell Biology, reflecting Ausubel's perspective that meaningful learning is an active process that includes the reception, assimilation, and application of new information. Given Ausubel's focus on the teacher's role as a facilitator, employing concept mapping in the instruction of Cell Biology is consistent with this viewpoint. Instructors have the capacity to assist learners in developing their concept maps, offering valuable support and constructive feedback. This collaborative strategy improves the learning process by ensuring that the maps precisely represent the subject matter and correspond with the students' existing cognitive frameworks.

In summary, Ausubel's Meaningful Learning Theory offers a robust theoretical framework for comprehending how concept mapping teaching strategies influences the success of Biology students, particularly in the complex area of cell study. The theory highlights the importance of meaningful connections, the organisation of knowledge, and the use of advance organisers, which aligns effectively with the goals of integrating concept mapping into the teaching strategy, potentially improving the effectiveness of Biology education for students.

2.2.2 Constructivism Learning Theory

Constructivist Learning Theory serves as a psychological and educational framework that emphasises the active role of learners in constructing their understanding and knowledge of the world. Instead of merely absorbing information, individuals actively participate in cognitive processes to interpret new experiences by leveraging their prior knowledge. At its essence, Constructivist Learning Theory is influenced by Jean Piaget's cognitive development theory. Piaget suggested that cognitive development takes place through assimilation and accommodation, as individuals incorporate new information into their existing cognitive structures or modify their mental frameworks to fit new experiences[55].

This theory also emphasizes the active role of learners in the educational process. It posits that individuals learn best when they actively participate in the construction of their knowledge. This active engagement may involve problem-solving, critical thinking, and hands-on experiences that prompt learners to reflect on and adapt their understanding. Social constructivism, an extension of constructivist theory, emphasizes the social nature of learning. Proposed by Lev Vygotsky, it asserts that social interactions and collaborative activities play a crucial role in the construction of knowledge. Learners benefit from engaging in discussions, group work, and collaborative problem-solving to co-construct meaning[56].

Vygotsky put forth the idea of the Zone of Proximal Development (ZPD), which illustrates the spectrum of tasks that learners are capable of completing with assistance from someone more knowledgeable. This concept emphasises the significance of scaffolding, wherein educators or peers offer assistance to learners as they confront challenges that slightly exceed their existing abilities. The Constructivist Learning Theory emphasises the importance of existing knowledge in the educational journey. This indicates that people engage in the process of linking new information to their pre-existing mental frameworks, associating new ideas with their current knowledge base. This strategy of expanding on existing knowledge fosters a deeper and more cohesive comprehension[57].

Authentic learning environments are considered essential in constructivism. These environments mirror real-world scenarios and provide learners with meaningful tasks and challenges. Authentic learning experiences allow individuals to apply theoretical knowledge in practical contexts, enhancing the transferability of their learning to real-life situations. Reflection is a key component of constructivist learning. Learners are encouraged to reflect on their experiences, thoughts, and problem-solving processes. This metacognitive aspect promotes selfawareness and enables individuals to monitor and regulate their own learning. Constructivism views learning as a continuous, lifelong process. It rejects the notion of a fixed body of knowledge that individuals passively absorb. Instead, learning is seen as an ongoing, adaptive process where individuals continuously construct and reconstruct their understanding based on new experiences and insights. Constructivist Learning Theory recognizes and values individual differences among learners. It supports personalized and students-centered strategies, acknowledging that each learner brings a unique set of experiences, perspectives, and prior knowledge to the learning process. This emphasis on individuality fosters a more tailored and effective educational experience[58].

Constructivism is a learning theory that posits knowledge is most effectively acquired through reflection and the active construction of understanding in the mind. Therefore, understanding is a shared interpretation among individuals. The individual engaging with the material must reflect on the information presented and, drawing from previous experiences, personal perspectives, and cultural contexts, formulate an understanding. Constructivism is divided into two primary factions: radical and social. The initial form of radical constructivism suggests that the knowledge construction process relies on the individual's personal interpretation of their active experiences. The second form of social constructivism posits that human development is embedded within social contexts and that knowledge emerges through interactions with others. This chapter discusses the history, practice, examples in education and limitations. History there is three foundational psychologists of constructivism. Jean Piaget falls into the radical constructivism camp. Lev Vygotsky, on the other hand, concentrates on the social aspects of learning through experiences. John Dewey straddles the line between the two perspectives and has many ideas that match with each side. The common ground that united these psychologists under the umbrella of constructivism is that all three believed that the learning theories (examples are behaviorism and humanism) at the time did not adequately represent the actual learning process. In addition, their ideas were rooted in experiences in the classroom instead of experiments in a lab (compared to behaviorism)[58].

The constructivist strategy emphasizes that the active construction of knowledge by the learner is socially and culturally rooted. This emphasis raises an interesting dilemma for the teacher, which is, how seriously should the teacher take the socially and culturally rootedness of the learner's construction of knowledge? A traditionalist might argue that the students social and cultural preconceptions are essentially subjective and should be left out of the classroom and that the students should engage in the learning experience on a purely rational and objective basis. But the constructivist strategy highlights the subjective nature of the construction of knowledge and this claim is particularly relevant for the social sciences where essentially the Students is studying the actions and interactions of human beings in areas such as politics, economics, society and culture. In the social sciences human beings are essentially studying their own actions and interactions and there is something inherently subjective about such an exercise[59].

However, this is not to deny the importance of objectivity and the capacity for abstract thought in academic endeavor even about our own actions and interactions. For a teacher in the social sciences the best way to resolve the dilemma raised by the constructivist emphasis on the subjective and socially and culturally rootedness of the construction of knowledge by the learner is to encourage the learner to the reflect objectively and rationally on his/her subjectivity and the social and cultural roots of his/her preconceptions and to channel them into a productive learning experience[60].

Relevant of Constructivism Learning Theory on the Effectiveness of Concept Mapping Strategy on the Achievement of in Biology Students

The constructivism learning theory is essential for comprehending how the concept mapping strategy impacts the performance of Biology students, particularly regarding the topic of cells. Firstly, it is important to note that constructivism highlights the active role of learners in building their knowledge through engagement with their surroundings. In the realm of Biology education, this indicates that students are more inclined to understand and remember information about cells when they are actively involved in constructing concept maps. Concept mapping aligns with a constructivist strategy by enabling individuals to visually organise and connect information, thereby promoting a deeper understanding.

Additionally, constructivism highlights the importance of the social dimension in the learning process. For pre-service teachers, engaging in collaborative concept mapping activities fosters discussions, facilitates the exchange of ideas, and encourages peer-to-peer teaching. The interactions contribute significantly to the development of personal understanding and create an opportunity for the sharing of varied viewpoints, thereby enriching the overall learning experience. The social dimension holds significant importance in the Biology topic, as it frequently encompasses intricate concepts that gain from diverse perspectives and dialogues. The constructivist perspective emphasises the significance of existing knowledge in the learning journey. Incorporating concept mapping into the teaching of Cell Biology allows students to merge their prior knowledge with new insights, fostering significant connections. This facilitates the retention and application of knowledge, allowing individuals to expand upon their current cognitive frameworks. The interactive aspect of concept mapping resonates with constructivist principles, promoting learners to contemplate their existing knowledge and weave it into a unified structure.

Constructivism highlights the importance of the teacher acting as a facilitator instead of merely passing on knowledge. Within the framework of the concept mapping strategy, educators facilitate the development of maps by students, promoting critical thinking and independent connection-making. This strategy encourages individuals to take charge of their learning journey, resonating with the idea that knowledge is built through active engagement rather than simply absorbed. It acknowledges the significance of applying knowledge in real-world contexts. Employing concept mapping in the Biology classroom enables students to link theoretical ideas regarding cells to real-world applications. This connection to real-world situations increases the significance of the learning experience, rendering it more impactful and useful. In conclusion, the constructivist learning theory offers a theoretical framework that bolsters and improves the effectiveness of the concept mapping strategy in enhancing the performance of Biology students, especially regarding their comprehension of cellular Biology concepts.

Constructivism recognises that learning is a continuous journey, where individuals consistently enhance and modify their comprehension through new experiences and insights. In the context of concept mapping, this supports the notion that learners can consistently revise and enhance their maps as their comprehension of Cell Biology develops, fostering a deeper and more intricate understanding over time. Furthermore, constructivism highlights the significance of metacognition, prompting learners to contemplate their own cognitive processes. When students create concept maps, they are encouraged to analyse the connections among various cellular components critically. This level of awareness enhances comprehension of the subject, as individuals gain insight into their cognitive processes and the rationale for the connections they create in their concept maps.

Furthermore, the constructivist perspective emphasises the diverse array of personal learning styles and preferences. Concept mapping addresses this diversity by providing a flexible tool that allows pre-service teachers to visually represent content in a way that corresponds with their unique cognitive processes. The customisation of educational resources fosters a student-centered strategy, aligning with constructivism's emphasis on tailoring education to individual needs and cultivating a more inclusive learning environment. Moreover, constructivism recognises the importance of learning experiences that are embedded within a particular context. Within the realm of Biology teaching, this entails establishing connections between cellular principles and tangible instances and implementations. Concept mapping enables students to incorporate actual scenarios into their maps, so strengthening the relationship between Cell Biology and real-life situations. This pragmatic strategy not only improves comprehension but also fosters a sense of inquisitiveness and admiration for the topic at hand.

Ultimately, the constructivist learning theory offers a comprehensive framework that beyond mere knowledge acquisition. The evidence suggests that when concept mapping is in line with constructivist ideas, it enhances the overall learning experience for pre-service Biology instructors. Constructivism improves the effectiveness of the concept mapping strategy in helping students develop a thorough understanding of cells by taking into account the continuous nature of learning, encouraging metacognition, accommodating different learning styles, and emphasising real-world applications[61].

2.2.3 Vygotsky's Social Development Theory

Social Development Theory, also known as Sociocultural Development Theory, is based on the findings of Lev Vygotsky, a notable Russian psychologist who lived from 1896 to 1934. The acknowledgement of Vygotsky's contributions in Western contexts was restricted until the 1980s. His untimely passing at the age of 38 left his theories incomplete, though translations of some of his Russian papers continue to be undertaken. Vygotsky's theory of social development suggests that a child's cognitive growth and learning potential are shaped and enhanced through their social interactions. Vygotsky's Socio-cultural theory asserts that learning is primarily a social process, emphasising the collective nature of knowledge acquisition over solitary exploration. He explains that a child's learning is significantly improved when they receive guidance from a more knowledgeable individual in the community, like a parent or teacher. Vygotsky's sociocultural theory suggested that infants learn and acquire knowledge through the beliefs and attitudes present in their social surroundings. He asserted that cultural factors played a crucial role in shaping cognitive development, leading to differences among various civilisations. Vygotsky highlighted the importance of language as the essential foundation for all learning[62].

Furthermore, the theory highlights the essential role of social interaction in the processes of learning and cognitive development (Vygotsky, 1978). Vygotsky posited that social learning precedes developmental processes. He asserts that every function involved in a child's cultural development occurs in two stages: initially, on a social level, and subsequently, on an individual level; first, between individuals (inter-psychological), and then within the child (intra-psychological). Lev Vygotsky's Social Development Theory highlights the essential role of interpersonal interactions in human cognitive development, positioning social interaction as a fundamental element.. Vygotsky postulated that the process of learning is inherently social in nature, and that significant cognitive growth is achieved through active engagement and cooperation with one's peers. Within this particular framework, the interchange of ideas, thoughts, and experiences among individuals serves as a catalyst for cognitive development. Social contact encompasses more than just formal instruction; it also includes ordinary encounters, play, and shared experiences[63].

Language is of utmost importance in the context of social interaction according to Vygotsky's framework. He contended that language serves not only as a medium of communication but also as a cognitive instrument. Language enables individuals to assimilate knowledge and participate in cognitive processes. Engaging in dialogues, conversations, and collaborative problem-solving allows individuals to actively negotiate the interpretation of information, exchange viewpoints, and collectively build knowledge. The inherent sociability of language enables individuals to not only convey their present comprehension but also to investigate and broaden their cognitive limits[64].

The Zone of Proximal Development (ZPD) is closely connected to social interaction. The Zone of Proximal Development (ZPD) denotes the disparity between a student's existing competence in executing a task with the support of an adult or peers, and their capacity to independently resolve the issue. Vygotsky posited that learning occurs within this particular zone. A scenario demonstrating the Zone of Proximal Development (ZPD) could involve a young girl encountering her initial jigsaw puzzle. On her own, she is probably not equipped to effectively put together the puzzle. When the child's father participates in a collaborative activity with her, showcasing essential strategies such as recognising corner and edge pieces, and supplies several puzzle pieces for the child to put together on her own while giving encouraging feedback, the likelihood of the child succeeding is enhanced. As the child's abilities develop, the father provides the young one with increased independence in their tasks. Vygotsky (1978) defines the Zone of Proximal Development as the particular range where optimal instruction or guidance should be offered to a child. This allows the child to develop skills that they will later be able to use independently[64].

Vygotsky proposed that optimal learning takes place when individuals are provided with guidance in tasks that fall within their Zone of Proximal Development (ZPD), which refers to the gap between their autonomous capabilities and their potential achievements with assistance. Engaging in social interaction, particularly with a more knowledgeable individual (MKO), is essential in offering the required support and scaffolding to aid learners in closing the disparity between their current skills and their potential[64].

This theory highlights the importance of supporting children's learning by involving them with a more cognitively advanced individual (MKO). An individual characterised as having a greater level of expertise concerning the task or topic that the younger person is trying to achieve or understand is referred to as the "more knowledgeable other." This role is generally taken on by a parent, career professional, or teacher, but it may also be filled by a peer or mentor. This strategy is not limited to just academic or instructional contexts; it can also be broadened to include recreational learning activities, such as playing games or using technology. In these circumstances, it is more likely that a peer or older child will possess a higher level of expertise. The MKO can serve as an electronic tutor, especially in contexts where a program is tailored to enhance learning via voice prompts or films. Vygotsky's theory highlights the importance of supporting children's learning through interactions with individuals who have more knowledge and expertise, referred to as a more knowing other (MKO). The concept of the "more knowledgeable other" denotes a person who has a greater degree of expertise related to the task or subject that the learner is trying to achieve or understand. Generally, the individual occupying this position would be a parent, carer, or educator, though it could also be a colleague or guide[65].

Vygotsky highlights the significant impact of culture on cognitive development. According to Vygotsky, the cognitive development and content of children's thoughts are shaped by the environment in which they are raised. Therefore, Vygotsky posits that cognitive development differs throughout cultures. Young children possess inherently restricted memory capacities. Nevertheless, society plays a decisive role in shaping the specific memory strategys individuals acquire. As an illustration, note-taking is taught in our society as a means to enhance memory retention. In communities without written language, alternative strategys were likely devised, such as using knots in a thread as a mnemonic device, carrying pebbles as a memory aid, or repeatedly reciting the names of ancestors to retain a huge amount of information. Vygotsky posits that cognitive functioning and development are influenced by the beliefs, values, and tools of the culture in which an individual is raised, therefore being socio-culturally determined. The cognitive development and functioning tools differ between cultures, as illustrated by the case of memory[65].

Consistent with the aforementioned statement, Vygotsky placed significant emphasis on the notion that social interaction takes place within a certain cultural and historical framework, hence influencing how individuals see the world and gain knowledge. Language, symbols, and common habits, known as cultural tools, have a role in facilitating social interactions and shaping cognitive development. An individual's cultural and societal background serves as the foundation for comprehending and analysing information. Consequently, social interaction occurs not just at an individual level but is also strongly ingrained in the wider cultural framework, thereby enhancing the variety of cognitive processes among various tribes and societies[65].

Relevant of Vygotsky's Social Development Theory on the Effectiveness of Cooperative Learning Strategy on the Achievement of Biology Students

Vygotsky's Social growth Theory highlights the significance of social contact in the process of cognitive growth. According to this view, learning takes place through social collaboration, and individuals develop knowledge through their interactions with others. Cooperative learning strategies harmoniously correspond with Vygotsky's concepts when applied to the field of education. Cooperative learning is a pedagogical strategy where students collaborate in small groups to collectively accomplish shared objectives, hence creating a social atmosphere that nurtures cognitive growth[66].

The cooperative learning technique can be particularly effective in the setting of Biology students. The field of Biology frequently encompasses intricate concepts and processes that can be more effectively understood through dialogue and cooperation. Through participation in cooperative learning activities, students have the opportunity to collaborate, communicate their viewpoints, exchange thoughts, and jointly develop a more profound comprehension of biological concepts. The cooperative strategy employed here reflects Vygotsky's conviction that social interactions play a crucial role in fostering the growth of advanced cognitive abilities[66].

Moreover, cooperative learning enhances the Zone of Proximal Development (ZPD), which is another fundamental principle in Vygotsky's theory. The Zone of Proximal Development (ZPD) delineates the spectrum of tasks that a learner is capable of accomplishing with the assistance of a more competent individual, such as a peer or instructor. Within a cooperative learning environment, students have the opportunity to support one another by providing scaffolding to facilitate the acquisition of intricate biological concepts, while operating within their own zones of proximal development (ZPDs). This reciprocal assistance improves their comprehension and equips them for proficient instruction in the future. Cooperative learning, being a social activity, also caters to the emotional aspect of education. Vygotsky's theory recognises the importance of emotions and motivation in the process of learning. Collaborative work not only improves the cognitive development of students but also creates a good and supportive learning atmosphere. The group's collective sense of belonging and shared duty can have a positive influence on the pre-service teachers' drive to thrive in their Biology studies and future teaching pursuits[67].

Furthermore, Vygotsky's Social Development Theory emphasises the influence of cultural and social factors on the process of learning. Cooperative learning inherently integrates a variety of viewpoints and experiences within a collective. For Biology students, this is especially beneficial since it provides them with exposure to a range of teaching strategies, cultural perspectives, and various strategies for explaining biological processes. Engaging with peers from other backgrounds and experiences enables students to enhance their ability to adjust their teaching strategies to cater to the varied students groups they may meet in their future classrooms[67].

Additionally, Vygotsky's theory highlights the significance of language in the process of cognitive growth. Cooperative learning fosters dynamic verbal conversation and discussion among participants. By expressing their opinions and elucidating topics to their classmates, teachers strengthen their own comprehension of biological principles. The linguistic component of cooperative learning is consistent with Vygotsky's concept of "inner speech," in which language functions as a cognitive tool. Engaging in meaningful discourse can enhance students understanding of biological topics, hence improving their overall pedagogical ability[68].

Furthermore, the collaborative nature of cooperative learning aligns with the constructivist strategy to education, which posits that learners actively build their understanding by connecting new information to their existing mental frameworks. Vygotsky's Social Development Theory enriches constructivism by emphasising the importance of social interaction in knowledge production. Collaborative learning in student education in Biology allows individuals to integrate new biological knowledge into their existing frameworks through active engagement in discovery and discussion. This procedure enhances comprehension of the subject while promoting a reflective and adaptable teaching strategy[68].

In summary, Vygotsky's Social Development Theory provides a robust theoretical framework for understanding the effectiveness of cooperative learning strategies in the training of future Biology educators. Cooperative learning, highlighting the social and collaborative aspects of the educational process, aligns with Vygotsky's theories. This strategy can significantly enhance the cognitive development, utilisation of the Zone of Proximal Development (ZPD), and motivation among Biology students. This strategy not only deepens their understanding of the topic but also equips them with essential collaboration and instructional skills for their future educational environments[69].

2.2.4 Social Interdependence Theory

Social Interdependence Theory is a conceptual framework created by psychologist Morton Deutsch during the mid-20th century. Its purpose is to comprehensively comprehend and elucidate the intricacies of social relationships and the dynamics of group interactions. The thesis is based on the concept that individuals' cognition, emotions, and actions are shaped by their interconnectedness with others. The essence of SIT is in the concept of interdependence, which denotes the reciprocal reliance individuals have on one another to accomplish shared objectives[70].

Social Interdependence Theory (SIT) proposes that individuals are not independent entities, but rather, they are interconnected within a broader social framework, where their achievements and results are interconnected with those of others. Interdependence can manifest in different ways, including positive interdependence, where individuals depend on each other for mutual achievement, or negative interdependence, when the success of one person comes at the cost of another[70].

Social interdependence theory categorises interdependence into two primary forms: cooperative interdependence and competitive interdependence. Cooperative interdependence arises when individuals recognise that their objectives can only be accomplished through working together and providing mutual assistance. Competitive interdependence occurs when individuals perceive that their success is dependent on surpassing others. The form of social interactions and relationships is greatly influenced by the type of interdependence that exists in a given circumstance. The theory also highlights the significance of goals in determining dependency. According to the theory, the level of interdependence depends on the goals that individuals are trying to achieve. Shared goals among individuals tend to promote good interdependence, which in turn encourages cooperation and collaboration. On the other hand, when goals are in conflict, it can result in negative dependency, which in turn can initiate competitive dynamics[71].

In addition, social interdependence theory presents the notion of positive and negative social dependency systems. Positive interdependence structures foster collaboration and synergy, as individuals acknowledge that their achievements are interconnected. Conversely, negative interdependence structures can result in rivalry and discord, since the achievement of one person may be detrimental to others. The theory emphasises the influence of communication and interaction patterns on social interdependence. Efficient communication and favourable interactions are crucial for establishing and sustaining cooperative dependency. On the other hand, misunderstandings or unfavourable interactions can worsen conflicts and strengthen the reliance on competition between parties. Furthermore, the social interdependence theory (SIT) suggests that the degree of interdependence between persons might have an impact on their attitudes and perceptions. Positive interdependence promotes favourable attitudes, trust, and a shared sense of identity, whereas negative interdependence can result in mistrust, competition, and a concentration on personal interests[72].

Relevant of Social Interdependence Theory on the Effectiveness of Cooperative learning Strategy on the Academic Achievement of Biology Students

The Social Interdependence Theory (SIT) is essential for comprehending how cooperative learning strategies impact the success of Biology students. Cooperative learning is an educational strategy in which students collaborate in small groups to reach shared objectives. Social Interdependence Theory, formulated by David W. Johnson and Roger T. Johnson, posits that the outcomes of individuals are interconnected; indicating that the achievement of one individual is associated with the achievements of others within a group. Social interdependence theory classifies interdependence into two distinct structures: positive, which encompasses cooperation, and negative, which involves competition. Cooperative learning strategies aim to cultivate positive interdependence, establishing social interdependence theory as a fundamental framework for comprehending the dynamics of group learning[73].

Furthermore, Cooperative learning strategies automatically foster good interdependence among group members. Within the framework of students specialising in Biology, this implies that their achievement is interconnected with the achievement of their fellow students. When individuals perceive a connection between their achievements, they are more inclined to engage in collaboration, resource sharing, and mutual support in their pursuit of learning. Furthermore, social interdependence theory highlights the significance of collective objectives and shared resources among individuals in a community. Shared objectives in cooperative learning environments for pre-service teachers may encompass the acquisition of specific Biology ideas, the cultivation of proficient teaching practices, and the improvement of communication abilities. Through collaborative efforts, pre-service teachers can combine their expertise and available materials, resulting in a more holistic comprehension of the subject matter[74].

Social interdependence theory emphasises the significance of favourable interpersonal connections in improving group dynamics. Cooperative learning promotes the development of social relationships among pre-service teachers, hence establishing a nurturing educational setting. Positive interpersonal connections foster a feeling of inclusion and reciprocal admiration, so exerting a beneficial impact on the collective accomplishments and contentment of individuals within the collective. Implementing cooperative learning strategies, particularly in the context of Biology instruction, enables pre-service teachers to actively participate and collaborate in their engagement with the subject matter. Engaging in activities such as group discussions, problem-solving exercises, and joint projects adhere to the concepts of social interdependence theory. These activities foster positive interdependence and improve the overall effectiveness of the learning process[74].

The theory of social interdependence highlights the notion that when there is a positive interdependence among group members, it results in the active engagement and involvement of all individuals within the group. Cooperative learning practices, which are based on the concepts of social interdependence theory, guarantee that students participate actively in conversations, problem-solving, and collaborative activities. Active participation in this activity not only improves their comprehension of biological ideas but also cultivates their abilities in critical thinking and communication. Cooperative learning, driven by social interdependence theory, promotes the exchange of varied viewpoints and knowledge among group members. Within the realm of Biology, students may possess diverse experiences, cultural backgrounds, or prior knowledge. Through engaging with fellow students and exchanging their distinct perspectives, they enhance the overall comprehension of the topic, cultivating a more inclusive and thorough educational atmosphere[75].

Social interdependence theory focuses on the concept of social loafing, which refers to the tendency of individuals to reduce their effort when working in a group. When cooperative learning practices are organised to encourage positive interdependence, they effectively reduce social loafing by prioritising individual accountability. Students develop a sense of responsibility towards their colleagues, resulting in heightened motivation and exertion as they acknowledge the influence of their contributions on the collective achievement of the group. In addition to acquiring proficiency in biological material, cooperative learning guided by social interdependence theory facilitates the cultivation of diverse skills crucial for proficient teaching. students acquire not just specialised knowledge in their subject area, but also refine their abilities in collaboration, communication, and leadership. These skills can be applied to their future classrooms, equipping them to provide captivating and cooperative learning environments for their students[76].

2.3 Review of Empirical Studies

2.3.1 Concept Mapping and Biology Students Academic Achievement

This study investigated the effects of employing the concept mapping teaching technique on the academic performance of high school students in Biology. The investigation was guided by two research objectives and three null hypotheses, utilising a quasi-experimental research strategy. A total of 241 students were chosen from the study population across three schools in the Enugu Education Zone, utilising a multistage selection strategy. The instrument employed for data collection was the Biology Achievement Test (BAT). The data gathered from the study questions underwent analysis through the application of mean and standard deviation calculations. The hypotheses were further examined through Analysis of Covariance (ANCOVA) with a significance threshold set at 0.05. The results demonstrated that students taught Biology using concept mapping achieved higher levels of success than those who received instruction through traditional lectures. In the context of Biology achievement scores, female students demonstrated superior performance compared to their male counterparts when concept mapping was employed as a teaching strategy. The investigation revealed no significant correlation between teaching strategies and gender concerning students' average achievement scores in Biology. The findings highlighted the educational implications and offered recommendations, notably suggesting that science educators integrate concept mapping into their instructional strategies. This study is similar to the current study, with the difference that government educational institutions will be employed[3].

This paper introduces a teaching technique designed for laboratory lessons in a Human Parasitology course, which is part of the Biological Sciences Teaching Education Course at the Faculdade de Formação de Professores, Universidade de Pernambuco, FFPG – UPE, situated in Garanhuns, Brazil. The Concept Maps provided support for the proposed plan. These tools are based on the theoretical principles of Ausubel's Meaningful Learning Theory. The course was attended by a cohort of undergraduate Students in their 6th semester who were pursuing careers as middle and high school teachers specialising in biological sciences. Our observations indicate that the use of Concept Mapping has enhanced Students involvement and consequently increased the level of interest in lectures on Human Parasitology. Furthermore, the Concept Maps that were created demonstrated clear indications of gradual specialisation and comprehensive integration of the suggested concepts. Therefore, we contend that Concept Maps are valuable tools for instructing parasitology in laboratory sessions, enhancing the pedagogical strategies, and therefore increasing their potential significance for the advancement of a Teacher Education Course[8].

This study examines how concept maps influence the academic performance of higher secondary school students in Biology. This study aims to explore the effects of the idea map strategy on the academic performance of XI Standard Biology students. This investigation utilises an experimental research strategy. The sample comprised four individuals designated with the title "Jr." Colleges from Gadhinglaj Taluka were selected through a random selection strategy. The implementation of the concept map technique in Biology education demonstrated significant benefits for students at the higher secondary level[9].

The investigation sought to analyse the effects of Concept mapping as an instructional strategy on Chemistry performance, with a particular focus on gender differences. The investigation encompassed a cohort of 236 students drawn from four government schools located in Ludhiana city. The sample consisted of two distinct groups: one experimental group comprising 118 students and a control group also consisting of 118 children. All students were in the IX class. The experimental group underwent the concept mapping strategy, while the control group experienced the traditional lecture and discussion strategy. The Mixed Group Intelligence Test (MGTI) created by Mehrotra (2008) was utilised to align the groups. The researcher employed a Chemistry achievement test that they created and standardised to gather data. The findings of the study indicated that the group taught through Concept mapping demonstrated notably greater levels of achievement in Chemistry than the group instructed using the Conventional strategy. No notable differences were observed in the academic performance of male and female students within the experimental group in the subject of Chemistry[11].

The study investigated the effects of employing the Concept Mapping instructional technique on academic performance in secondary schools in Nigeria. The study employed a Quasi-Experimental Research design. A purposively selected sample of 168 Senior Secondary School Class-two Physics Students was drawn from various Senior Secondary Schools in Ekiti State, Nigeria. The tool employed for the study consisted of two parts: a) a Motion Concept Map tailored for the research study, and b) printed materials consisting of tutorial test items that were created and utilised to gather responses to the therapy. The study investigated whether the treatment significantly influenced students' learning achievement, retention, and learning attitude. The study revealed that employing the Concept Mapping Instructional strategy had a beneficial effect on learning outcomes in physics. The study also demonstrated a significant impact of the treatment on students' retention of learnt material and their overall attitude towards learning. The results indicated that integrating the instructional strategy with various teaching strategies resulted in improved academic performance[12].

This investigation explored the effects of lectures, cooperative learning, and concept maps on the improvement of critical and creative thinking skills. The investigation employed a quasi-experimental non-randomized design, incorporating a cohort of third-year Psychology students alongside two cohorts of third-year Pre-service Elementary Teachers. The study was conducted over a period of 15 weeks, which corresponds to one semester. One of the Primary School Teaching classes incorporated both cooperative learning and concept maps, whereas the other class exclusively used cooperative learning. The Critical and Creative Thinking exam was conducted to assess the levels of critical and creative thinking abilities before and after the intervention. The results demonstrate that students in the two classrooms utilising cooperative learning and cooperative learning combined with concept maps exhibited significant improvements in critical and creative thinking skills when compared to the class that followed traditional lecturing strategies. Interestingly, there were no significant differences observed between the first two classes. Drawing from these data, instructional recommendations are offered[13].

The investigation explored the impact of employing the concept mapping instructional technique on the academic performance and long-term knowledge retention of underperforming Biology students in senior secondary schools within Minna Metropolis. The investigation employed a quasi-experimental design. The investigation involved a sample of 86 underperforming students from two senior secondary schools in Minna Metropolis, focussing specifically on the SS1 level. The tool used for data collection was the Biology Achievement Test (BAT), which received validation from experts in Science Education, specialists in

Biological Science, and Biology instructors. The internal consistency was evaluated through the Pearson Product Moment Correlation strategy, resulting in a coefficient of r=0.85. The results indicated a significant difference in the average achievement scores between low-achieving Biology students who received instruction using concept maps and those who were taught through the conventional lecture strategy. The results demonstrate that the use of concept maps was more effective in enhancing the academic performance of underperforming students in Biology than the conventional lecture strategy. It is advisable to promote the re-training of educators in the application of concept mapping instructional techniques to enhance the performance and retention of low-achieving Biology students[14].

The impact of students' self-efficacy beliefs on their academic achievement and motivation throughout all stages of their academic journey has garnered considerable attention from many scholars. It greatly improves the overall development and success of the students, even as they progress to the next phase of their educational journey. This quasi-experimental study sought to investigate the effects of employing the concept mapping strategy as an intervention on improving students' self-efficacy beliefs related to their motivation and achievement in Biology. A total of 120 students from two different senior high schools in the Ashanti Region of Ghana took part in the experiment. The data collection utilised two instruments: a questionnaire assessing students' self-efficacy and motivation, along with an achievement exam. The analysis of the results employed statistical strategies such as Pearson product-moment correlation, one-way ANOVA, and multiple regression. The findings of the study indicate that the regular and effective application of the concept mapping technique greatly enhances students' self-efficacy beliefs about their progress, thereby increasing their motivation to learn and succeed in Biology[15].

The objective of this study was to assess the efficacy of utilizing concept maps in enhancing the academic achievement of 10th-grade Students in the field of science, specifically in a Biology unit, and to compare it with a conventional instructional strategy. Additionally, the researchers examined the correlation between the Students proficiency in concept mapping and their academic progress. Both the control and experimental groups were mandated to complete a pretest prior to teaching and a posttest at the conclusion of three weeks. A 31-question test was administered to evaluate the extent of learning progress made on a Biology Unit focused on the concept of Balance in Nature. Novak's grading scheme was utilized to evaluate the maps created by the Students. The initial discovery of the study revealed that Students who were exposed to concept maps did not exhibit significantly superior achievement compared to Students in the traditional group who were at the same level. The observed disparity in the educational advancements between the experimental and control groups on their unit examination, while statistically significant, does not appear to be exclusively attributable to the utilization of concept mapping. The second conclusion revealed that there was no significant correlation between total scores in concept maps and Students achievement in Science. In addition, the findings indicated that there was no correlation between the proficiency in concept mapping and the learning progress of Students who used concept mapping. However, the study indicates that concept mapping can be an effective instructional strategy when it is carefully incorporated into the regular classroom routine and when other factors such as Students motivation and preparedness, reading ability levels, time, and classroom environment are taken into account[16].

The investigation explored the comparative effectiveness of the concept-mapping teaching strategy versus the traditional strategy to delivering secondary school physics content to students. The study employed a quasi-experimental research design. The population comprises all senior secondary school II physics students in Ekiti State. A sample comprising eighty physics Students from senior high school two were randomly assigned to either a concept-mapping group or a traditional group. Each participant received specific guidance on the principles of motion. The groups participated in a post-test following a two-week treatment period to assess any significant differences in physics achievement. The examination of the post-test scores indicated that the group taught with the concept-mapping instructional technique attained significantly superior results ($P < 0.05$) in comparison to the conventional group. The results demonstrate that the implementation of the concept-mapping instructional strategy, in conjunction with other teaching strategies, resulted in improved learning outcomes[17].

This study aimed to compare the concept mapping strategy, which is based on constructivist theory, with the conventional strategy to teaching Biology in Senior High Schools. Two complete classes were selected at random from a pool of five co-educational senior high schools offering elective biology courses in the New Juaben Municipality. The design utilised was a pretest and post-test non-equivalent quasi design. The sample size included 105 students. The experimental group consisted of 51 students, while the control group included 54 students. The participants in the experimental group were instructed using concept mapping, while the control group underwent traditional instructional strategies. Both groups were provided with the same instruction regarding the subjects of photosynthesis and internal respiration. The data analysis utilised various statistical tools such as means, standard deviations, frequencies, the Mann-Whitney U test, independent sample t-test, and paired sample t-test. The results indicated that participants who were taught through concept mapping achieved better outcomes than those who were instructed using conventional strategies. The findings indicate the importance of encouraging the use of concept mapping techniques across various Biology subjects in Senior High Schools[4].

The investigation explored the effects of a collaborative concept mapping teaching strategy on the academic performance and knowledge retention of senior secondary school students in the area of ecology in Benue state, Nigeria. The investigation was guided by four specific aims. Four questions were formulated and explored, while four hypotheses were developed and tested at a significance level of 0.05. The investigation employed a quasi-experimental design that included a pre-test, post-test, and a control group. The study was conducted in the state of Benue. The investigation centred on a specific cohort of 16,322 senior secondary one (SS1) Biology students. The selection of these students was conducted from a pool of 96 government grant-aided secondary schools in Benue state, as documented by the Benue State Ministry of Education in 2018. A total of 217 senior secondary I Biology Students participated in the study. The selection of the sample was conducted through a multistage sampling technique. The data collection instruments included two tests developed by the researchers: the Ecology Achievement Test (EAT) and the Ecology Retention Test (ERT). The Kuder-Richardson strategy (formula K-R21) produced a reliability coefficient of 0.84.The questions posed in the study were addressed through the application of descriptive statistics, specifically the mean and standard deviation. Inferential statistics were employed to test the null hypotheses, utilising the Analysis of Covariance (ANCOVA) at a significance level of 0.05. The findings indicate that the use of collaborative concept mapping as an instructional technique in Ecology education can improve students' academic performance. The study indicated that educators should integrate collaborative concept mapping as a teaching strategy in Ecology to improve students' academic performance and knowledge retention[5].

This study examined the influence of concept maps on the academic performance of high school students in the area of ecology in Ogbomoso, Nigeria. A quasi-experimental design was employed. The study population included all SSII Biology Students in Ogbomoso South. A sample of 267 students was drawn from four intact classes, consisting of 115 males and 152 females. The tool employed was the Biology Achievement Test. The analysis involved the application of a t-test and covariance analysis to evaluate the data. The study's findings revealed a significant disparity in the performance of students who received instruction in ecological principles within the Biology curriculum. It is proposed that students in the field of Biology be introduced to concept maps as an effective learning tool for their studies[77].

This investigation utilised a quasi-experimental framework and included a cohort of 100 second-year medical students participating in an anatomy course. The participants were randomly assigned to either a control group (lecture-based) or an intervention group (concept mapping). The California Critical Thinking Skills Test was employed to assess the critical thinking levels of medical students. The analysis involved an independent samples t-test to evaluate the data. Before the intervention, the CT scores for the intervention and control groups were 6.68 ± 2.55 and 6.64 ± 2.74, respectively. Post-intervention, the scores rose to 11.64 ± 2.29 and 10.04 ± 3.11, respectively. The examination of mean score variations between the two groups prior to and following the intervention indicated a notable increase in CT scores within the experimental group post-intervention ($P=0.021$). The investigation revealed that Medical Students instructed via concept mapping exhibited a notable enhancement in CT scores compared to the control group. It is essential for medical students to develop strong CT skills to facilitate precise and informed decision-making in patient care. As a result, it is expected that educators and organisers of medical training will adopt this teaching strategy to foster critical thinking abilities in medical students[78].

The study was conducted at the Health Technical Institute situated in Tanta. The study comprised a total of 60 nursing students as participants. Tools: Data were collected using a revised concept mapping questionnaire and an evaluation of critical thinking skills. The findings revealed a significant correlation between concept mapping and critical thinking abilities among nursing students. A robust and statistically significant positive correlation was identified between concept mapping and critical thinking skills in nursing students. Suggestions: To improve nursing students' comprehension of concept mapping and critical thinking skills, it is recommended to develop and implement strategies that encourage the integration of concept maps and critical thinking in their academic activities. Furthermore, it is essential to promote active engagement among nursing students in innovative teaching strategies[79].

The article has been successfully transferred. The article received a recommendation. Concept maps serve as valuable instructional tools that utilise evidence to evaluate how effectively students have met their learning objectives in a significant manner. Furthermore, they offer clear insights to improve training and support a deeper understanding of the essential principles of learning. This study offers an in-depth analysis of concept maps and shares our direct experiences in applying concept maps across four essential dimensions of education: teaching, training, testing, and thinking[80].

The objective of utilising a mixed-strategy strategy alongside a comparative research design was to investigate the effects of the concept-mapping strategy on the economic learning and perceptions of international college students. A cohesive group comprising students from various countries was tasked with collaborating on a concept-mapping strategy. A distinct group, which was not affected by external factors, comprised individuals who communicated in English and served as a control group for comparative analysis. The participants in the intervention group employed the concept-mapping strategy while studying economics. The participants in the comparison group did not undergo any intervention or specialised instruction throughout the research duration. Assessments and midterm exams on economic knowledge were administered to both cohorts. After the study was completed, the students' proficiency in economics was evaluated through various strategies, including achievement exams like quizzes and midterms, scores from concept-mapping rubrics, and levels of classroom engagement. The application of the concept-mapping technique notably improved the academic performance of international students in economics. The results demonstrated a favorable pattern of quiz scores over time for four quizzes and two midterms in both groups. The findings further revealed no statistically significant difference in classroom engagement levels between the two groups. This indicates that international students with a conventional educational background were engaging at a comparable level to students from the US. The correlation coefficient between the overall score of concept mapping and the final grade indicates a modest positive relationship. The qualitative data uncovered six unique themes: (a) familiarity and utilization of the concept-mapping strategy, (b) available resources for developing concept maps, (c) advantages of using the concept-mapping strategy as identified by participants, (d) reasons for ambivalence towards the concept-mapping strategy, (e) alternative note-taking strategies employed by participants, and (f) participants' inclination to utilize the concept-mapping strategy in the future[81].

2.3.2 Cooperative Learning and Biology Students Academic Achievement

The investigation explored the effects of utilising a cooperative learning strategy on the academic performance and long-term knowledge retention of secondary II students enrolled in Biology in Ebonyi State, Nigeria. The investigation was guided by two research enquiries and a singular hypothesis, utilising a quasi-experimental strategy. The investigation encompassed a cohort of 24,459 secondary II students. A total of 161 students, comprising 78 males and 84 females, were selected from four co-educational boarding secondary schools through a simple random sampling strategy. Two schools were randomly designated as part of the experimental group, while the remaining two schools were assigned to the control group through a coin flip. The treatment group engaged in Biology instruction through the cooperative learning strategy, whereas the control group experienced Biology instruction via the standard strategy. The initial collection of data regarding student accomplishments was conducted through a Biology Accomplishment Test (BAT), which was subsequently adapted to assess knowledge retention. The enquiries were addressed by employing the measures of mean and standard deviation, while the hypothesis was examined through the use of ANCOVA at a significance level of 0.05. The results indicated that employing a cooperative learning strategy is more effective than traditional learning strategies in enhancing academic performance and ensuring long-term knowledge retention. It has been proposed that educators in the field of Biology adopt cooperative learning techniques to improve students' academic performance and knowledge retention[82].

This study investigates the effects of cooperative learning within a Biology classroom on students' development of scientific skills and their overall academic performance and success. A total of 120 students from grades seven and ten took part in the study conducted at a private school in Beirut. The investigation centred on the instruction of Biology across various classes in two distinct grades, employing two separate strategies: cooperative learning for the experimental group and individualistic-direct learning for the control group. Both groups in each grade participated in pre- and post-tests to evaluate student achievement, particularly in scientific skills, prior to and following the intervention. The findings of the study reveal that cooperative learning significantly influences the academic performance of tenth-grade students in developing and applying scientific skills. Nonetheless, there was no notable effect detected in the development of new scientific skills among seventh-grade students[83].

This study aimed to assess how effective the cooperative learning technique is in enhancing the mathematical performance of senior high school students in Sokoto State, Nigeria. A quasi-experimental design was employed, consisting of two separate groups: the control group and the experimental group. The investigation meticulously focused on three objectives, three research enquiries, and their corresponding null hypotheses. In this investigation, three schools were chosen at random in Sokoto. The focus of the study was on all senior secondary school II (SSS II) students. A total of 240 students were selected as samples from these three schools. The selection process involved intact classes, indicating that the whole class was incorporated into the study. The participants were allocated into experimental and control groups. The data collection instrument utilised was the "Mathematics Integration Achievement Test" (MIPT), consisting of 24 items. The validation of this test was carried out by three experts, resulting in a reliability coefficient of 0.88. The findings of the study reveal that collaborative learning strategyes provide significant benefits for mathematics education in secondary schools. The implementation of the cooperative learning strategy has been proposed as the most effective strategy and teaching strategy for mathematics instruction. The findings of the study suggest that this strategy enhances students' understanding of mathematics and improves their academic performance[84].

Cooperative learning is an educational strategy that involves students being grouped together to work collaboratively towards a common goal. Prominent learning theories suggest that optimal learning outcomes are attained when students engage in actively constructing their own knowledge within an environment that fosters active learning. This setting ought to promote social engagement and teamwork among learners, ultimately resulting in the achievement of a specific objective. Cooperative learning creates an effective learning atmosphere and offers the benefit of building an active learning community where students can develop skills applicable in multiple settings. The rise of online learning has consistently accelerated in recent years, witnessing even more significant expansion during the COVID-19 pandemic. Tertiary institutions were required to adopt online learning platforms as the exclusive strategy for delivering academic programs remotely. In light of the growing prominence of online learning, there is a call for educators to examine the intricacies of teamwork and collaboration, and to investigate strategies for enhancing these elements within a digital context. Fostering collaborative involvement in the online learning environment is essential to reduce feelings of isolation and promote deep learning experiences. In the second accounting module of a fully online degree, participants delve into a case study that encompasses both a collaborative assignment and a personal assignment component. This study aims to evaluate the effectiveness of collaborative efforts by analysing the grades earned through teamwork in contrast to those achieved independently[27].

Cooperative learning (CL) is a pedagogical concept that has been widely applied in the realm of Physical Education (PE), especially during the early training of educators. The aim of this study is to evaluate how well future physical education instructors can apply the training they have obtained at university, while also examining the anxieties, uncertainties, and challenges they face during its implementation. A total of thirteen individuals pursuing careers as physical education teachers, comprising seven females and six males, with an average age of 20.87 years, took part in the programme. The participants underwent extensive training in cooperative learning across various disciplines and applied it in their classrooms throughout their internship. The selection of individuals was conducted through purposive non-probability sampling strategys. The investigation utilised a qualitative strategy, incorporating interviews, teaching diaries, and seminars with the tutor as the main tools for data collection. Three analytical categories were utilised: (a) initial expectations regarding the implementation of the CL; (b) challenges encountered during its implementation; (c) reflections on its future application. The results indicated that aspiring educators did not observe the fulfilment of their expected accomplishments, as they faced resistance from both students and physical education teachers. Furthermore, they emphasise the importance of continuous training within a framework that includes numerous intricacies to ensure effective implementation. It is essential to persist in the investigation of a pedagogical framework within physical education, as it presents multiple avenues and carries considerable societal consequences[85].

Cooperative learning is an instructional strategy that has gained traction in recent years as a means of improving student achievement. This meta-analysis examines the effects of cooperative learning on student achievement by synthesising data from various published studies that met our inclusion criteria. A total of 35 studies were included in the analysis, and the findings indicated a significant and positive effect of cooperative learning on students' academic achievement. The moderate effect size indicates that cooperative learning serves as a highly effective instructional strategy for improving student achievement. The findings of the study carry important implications for theory, practice, and policy, suggesting that educators ought to integrate cooperative learning into their teaching strategys. It is crucial to acknowledge the limitations of this meta-analysis, including the possibility of publication bias and the variability among the studies that were included. Further exploration is necessary to address these limitations and assess the potential benefits of collaborative learning across different environments and populations[86].

Collaborative learning and cooperative learning represent unique strategies that were developed independently by different groups of scholars in the 1960s and 1970s. Due to their varied origins and linked developmental paths, they have distinct traits while also showing many commonalities. The relationship between collaborative learning and cooperative learning can be quite complex. This study provides a succinct historical overview of collaborative learning and cooperative learning, aiming to identify their origins, differences, and commonalities. This study examines the definitions of the two terms and compares their characteristics. Following this, a detailed analysis of their historical development over the last fifty years is provided: early progress in the 1960s and 1970s; enhancement in the 1980s and 1990s; incorporation in the mid-1990s; and the emergence of Computer-Supported Collaborative Learning (CSCL) in the late 1980s. This study offers a succinct summary of the four main paradigms in conventional investigations into collaborative and cooperative learning: the "effect" paradigm, the "conditions" paradigm, the "interaction" paradigm, and the "design" paradigm[87].

An assessment is carried out to analyse Cooperative Learning strategies in relation to conventional teaching strategies for students in grades 6-12. Grades 6-12 represent a crucial phase where students begin to explore various career paths and enhance their understanding of their role in the professional landscape. The inquiry focusses on whether cooperative learning leads to greater student achievement compared to traditional learning strategies. The investigation focused on five key indicators of student success: self-efficacy, academic achievement, meeting the needs of diverse learners, collaboration, and the promotion of critical thinking. The investigation of these markers was conducted to address the research question. An extensive examination was conducted on various strategies related to cooperative learning, including Teams Games Tournaments (TGT), Think Pair Share (TPS), Students Team Achievement Division (STAD), Collaborative Strategic Reading (CSR), Numbered Heads Together (NHT), Problem Based Learning (PBL), Jigsaw, Co-op Co-op, Reading-Concept-Map-Timed-Pair-Share (Remap-TmPs) model, Learning Together, Line@, Activity Based, and Collaborative Argumentation. The assessment of cooperative learning strategies in student learning was conducted using statistical techniques, including Analysis of Variance (ANOVA), Analysis of Covariance (ANCOVA), and SPSS 15.0 software. Most studies have found that cooperative learning strategies outperform traditional strategies in terms of effectiveness. Commonalities were identified in the focus to enhance the reader's comprehension of the effectiveness of cooperative learning in grades 6-12 worldwide[88].

This investigation analysed the effects of the Cooperative instructional strategy alongside the Concept Mapping-Guided Discovery integrated instructional strategy on the attitudes, achievements, and retention rates of Basic Science students. A straightforward random sampling strategy was employed to select 103 sixth-grade students from three public elementary schools located in the North-East Senatorial District of Benue State, Nigeria. The investigation employed a quasi-experimental framework. The investigation was guided by three primary questions and examined three hypotheses, all evaluated at a significance level of 0.05. The process of gathering data included the use of two particular instruments: the Basic Science Attitude Questionnaire (BSAQ) and the Basic Science Achievement Test (BAT). The assessment of the BSAQ's reliability was conducted through Cronbach Alpha, resulting in a value of 0.80. The reliability of the BAT was similarly established through split-half analysis, yielding a coefficient of 0.81. The results demonstrate that both instruments exhibited adequate reliability for the study. The issues of the study were tackled through Mean Gain scores, while the hypotheses underwent testing via Analysis of Covariance (ANCOVA). The magnitude of the alterations was assessed utilising Scheffe's post-hoc test. The findings of the study revealed significant differences in the engagement and knowledge retention of students taught using the cooperative instructional strategy and the Concept Mapping-Guided Discovery integrated instructional strategy, in contrast to those who were instructed through the Conventional Demonstration Strategy[89].

Cooperative learning (CL) is an advanced instructional strategy that utilises various motivational strategies to enhance the significance of lessons and promote greater learner accountability. This study sought to investigate the influence of cooperative learning on students' achievement in chemistry at the advanced level within 12-year basic education institutions. The study employed a quasi-experimental design, where one group was subjected to cooperative learning as the treatment, while another group acted as the comparison (control) group. The treatment group was taught organic chemistry through cooperative learning strategies, whereas the control group was instructed using conventional teaching strategies (CTM). A total of 257 students were included in the study cohort. The data was collected using an organic Chemistry Achievement Test and later analysed with SPSS version 23.0 and MS Excel 2016. The ANCOVA analysis indicated that students taught through cooperative learning strategies significantly outperformed those in the control group ($F=78.07$, $df=1, 256$, $p<.001$), showing learning gains of 16.0% for traditional strategies compared to 53.6% for the cooperative learning strategy. Nonetheless, the analysis revealed no statistically significant difference in the distribution of gender among the student population. Chemistry educators ought to receive training in cooperative learning and be motivated to integrate it into their instructional strategies to enhance students' academic performance[90].

2.3.3 Concept Mapping and Students Gender

This study aimed to compare the constructivist-based concept mapping strategy with the traditional strategy of teaching biology in senior high schools. Two entire classes were selected at random from a total of five co-educational senior high schools offering elective biology in the New Juaben Municipality. The design utilised was the pretest-post non-equivalent quasi design. A total of 105 students participated in the study. The experimental group consisted of 51 students, while the control group included 54 students. The participants in the experimental group were taught concept mapping techniques, whereas the control group was instructed using the traditional strategy. Both groups were provided with the same instruction regarding the subjects of photosynthesis and internal respiration. The analysis involved various statistical measures, including means, standard deviations, frequencies, Mann Whitney U test, independent sample t-test, paired sample t-test, one-way MANOVA, two-way ANOVA, Pearson's Product Moment Coefficient correlation, and thematic content analysis. The results indicated that participants who were taught through concept mapping demonstrated superior performance compared to those who were instructed via conventional strategies. The results demonstrated that both males and females constructed concept maps in a comparable fashion. Moreover, those who experienced concept mapping held a positive view of the technique. It has been proposed to encourage the implementation of concept mapping in biology classes at the senior high school level. Significant attention must be directed towards students concerning analysis and other subjects that require advanced cognitive abilities[6].

The investigation explored the effectiveness of employing the concept mapping instructional strategy to improve the academic performance of high school students in biology. The study was guided by two hypotheses that were examined at a significance level of 0.05. The investigation utilised a quasi-experimental strategy, purposefully selecting 122 Senior Secondary students from two senior secondary schools in Adamawa state. The instrument for data collection employed was an achievement test referred to as the Biology Students Achievement Test (BSAT), which was developed from WAEC tests conducted from 2005 to 2010. The instrument was subjected to content validation by three experts, and its reliability was evaluated through the Cronbach alpha formula. A dependability coefficient of 0.78 was obtained. The treatment lasted for six weeks, and the data were analysed using one-way Analysis of Covariance (ANCOVA). The findings indicated that the use of concept mapping strategy notably enhanced students' academic performance in the area of biology. Furthermore, no significant difference was noted between male and female students in the experimental group. Incorporating the concept mapping strategy into biology education is recommended to enhance meaningful learning experiences. Furthermore, it is essential to organise seminars for in-service and practicing educators to equip them with the skills necessary for the effective application of the concept mapping strategy[7].

This study aimed to determine the effect of the concept-mapping teaching technique on students' academic performance and their attitudes towards basic science. Fifteen research questions were formulated, and corresponding hypotheses were developed and evaluated at a significance level of 0.05. The investigation utilised a 2x2x2x2 factorial non-randomized pre-test post-test non-equivalent control group quasi-experimental design. The sample for this study included 214 students and six teachers, all chosen from six secondary schools located in the Delta Central senatorial district. The instruments employed for data collection included the Basic Science Achievement Exam (BSAT) and the Students Attitude Questionnaire (SAQ). The instruments were subjected to comprehensive validation, and their psychometric characteristics were evaluated to confirm their reliability before use. The collected data underwent analysis through descriptive statistics, paired sample t-test, independent sample t-test, and ANOVA. The main findings of the study included the following: The application of mapping concepts positively influenced students' academic performance. (ii) A significant difference was observed in the academic performance of students in the experimental group compared to those in the control group. (iii) A notable difference was observed in the academic performance of students attending single-sex schools compared to those in mixed-gender schools within the experimental groups. (iv) The academic achievement of students in the experimental group did not show any significant differences across varying abilities. There was no notable interaction between teaching strategy and gender regarding academic achievement. (vi) The analysis revealed that the combined influence of teaching strategy, gender, and ability did not significantly impact the academic achievement of students in basic science. The analysis revealed no notable interaction among teaching strategy, gender, and ability regarding attitude. The findings indicate that the concept mapping technique is an effective strategy for teaching basic science in educational settings. It is advisable for both educators and learners to receive adequate training to develop the necessary skills for utilising concept mapping, and they should be motivated to incorporate it into the teaching and learning process[10].

This investigation explored the effects of concept mapping and cooperative learning strategies on the academic performance of junior high school students in Social Studies in the Ika

South Local Government Area, Delta State. The study was designed with five enquiries and five proposed explanations. The investigation employed a quasi-experimental framework featuring a non-randomized pretest-posttest control group. The survey encompassed a sample of 5,522 students enrolled in public secondary schools within Ika South LGA. A total of 141 students from JSSII were chosen through a multistage sampling strategy. A 50-item instrument known as the "Social Studies Achievement Test" (SSPT) was utilised for data collection. The instrument was validated by a panel of seven experts. A reliability coefficient of 0.75 was obtained through the Pearson Product Moment Correlation. The research questions were addressed through the calculation of mean and standard deviation, and the hypotheses were evaluated using analysis of covariance (ANCOVA) at a significance level of .05. The results demonstrated that each of the independent variables significantly influenced the improvement of student achievement in Social Studies. Moreover, the concept mapping strategy produced similar advantages for both male and female students. Nonetheless, a disparity was noted in the performance of male and female students taught through the concept learning strategy, with female students demonstrating better results. The results and conclusions indicate that arranging seminars and workshops for Social Studies educators throughout the federation to impart strategies like concept mapping and cooperative learning could enhance the quality of teaching and learning in Social Studies Education. Incorporating concept mapping and cooperative learning strategies into the pre-service teaching strategies of the Nigeria Certificate in Education (NCE) and degree programmes is recommended, and implementing these strategies during the Teaching Practice Exercise[17].

This investigation explored the effects of the Concept-mapping teaching technique on the academic performance and knowledge retention of high school students studying biology in Lagos, Nigeria. The investigation employed a quasi-experimental research framework. The sample included all second-year biology students in senior secondary school. The investigation encompassed two entire classes of SS II students. The study utilised the Biology Achievement Test (BAT) and Concept-Mapping Based Lesson Plan (CMBLP) as its instruments. The reliability coefficients for the instruments were recorded at 0.75 and 0.82, respectively. The investigation was guided by three enquiries along with their corresponding hypotheses. The statistical strategy employed to evaluate the hypotheses at a significance level of 0.05 was Analysis of Co-variance (ANCOVA). The findings of the study reveal that the experimental group surpassed the control group, illustrating that concept-mapping positively influenced students' achievement and retention. Furthermore, the findings indicated that gender had no impact on students' achievement. The findings indicate that educators ought to be motivated to integrate the concept-mapping instructional strategy in their senior school biology teaching practices. Moreover, it is essential to enhance academic performance and retention among male students, akin to that of their female counterparts[18].

This study sought to explore the effects of Concept Mapping (CM) and Cooperative Mastery Learning (CML) on improving retention of photosynthesis concepts among secondary school students in the Nyamagabe region of Rwanda. A quasi-experimental design with a non-equivalent control group was utilised, incorporating both a pre-test and a post-test. A total of 151 students received instruction through CM, 144 students were taught using CML, and 154 students participated in Conventional Teaching Strategies (CTM). The Photosynthesis Retention Test was utilised for data collection, achieving a KR-21 reliability coefficient of 0.82. The analysis of the data was conducted mainly through the mean and Analysis of Covariance (ANCOVA). The results demonstrated that both the CM and CML treatment groups showed enhanced performance relative to the CTM group regarding photosynthesis retention. The two experimental groups exhibited a statistically significant difference favouring the CM. Male and female students instructed through CM demonstrated comparable retention in photosynthesis. Nonetheless, a notable difference in mean retention scores was identified among students exposed to CML, with females exhibiting significantly higher retention compared to their male counterparts. The findings indicated that the CM and CML techniques demonstrated greater efficacy in comparison to CTM. A recommendation was proposed to motivate educators to implement CM (Concept Mapping) and CML (Computer-Mediated Learning) strategies in their biology instruction[76].

This investigation aimed to explore the effects of concept mapping, a learning strategy rooted in constructivist principles, on the academic performance of seventh-grade students in general science. This investigation employed a quasi-experimental strategy, specifically utilising a 2x2 factorial design. The sample comprised 167 children enrolled in two single-sex educational institutions. The study sought to accomplish the following objectives: (i) to explore the influence of concept mapping as a learning strategy on students' academic performance, (ii) to analyse the varying effects of concept mapping on the academic success of male and female students, and (iii) to assess the interaction between concept mapping as a learning strategy and gender regarding students' academic achievement. An achievement test was employed, created by the individual, serving as both a pre-test and a post-test. During a five-month therapy period, the experimental group participated in a three-week training program aimed at enhancing the development of concept maps. Subsequently, the students autonomously developed concept maps focussing on various general science topics. The participants subsequently engaged in discussions about their maps with their colleagues in group settings. The educator analysed the students' maps alongside scientifically validated concept maps to pinpoint any possible inaccuracies or areas needing improvement. The evaluation of gain accomplishment scores was conducted through a two-way analysis of variance (ANOVA). The results showed that both male and female students taught through concept mapping achieved higher levels of success than those who received instruction through traditional teaching strategies. Nonetheless, male students who received instruction through concept mapping demonstrated significantly higher achievement than their female peers. Consequently, employing concept mapping as an instructional strategy for general science in elementary classrooms is recommended. Concept maps may also find application in science textbooks designed for school use[91].

2.3.4 Cooperative Learning and Students Gender

This investigation explores the effects of cooperative learning strategies on students' academic performance in Biology. This investigation employed a quasi-experimental strategy and centred around two research enquiries and two hypotheses. The population for this study comprised 1255 Biology students from 15 public secondary schools located in the Isi-Uzo L G A region. The investigation employed a sample size of 120 students. The instrument for data collection comprised previous WAEC questions in Biology, specifically chosen from the curriculum topics of Genetics, the Nervous System, and the Digestive System. The issues were examined through the application of mean and standard deviation, and the hypotheses underwent testing via ANCOVA. The results reveal a significant disparity between the cooperative learning strategy and the traditional learning strategy, with a clear preference for the cooperative learning strategy. The data-driven recommendations indicate that a significant emphasis should be placed on female students, given the observed trend of males outperforming females in cooperative learning settings. Biology instructors at the secondary school level ought to undergo thorough training on how to effectively implement cooperative learning strategies in their teaching of Biology[92].

This investigation explored the effects of introducing a cooperative learning strategy on the academic performance of students in Biology at Senior Secondary schools in Rivers State. The investigation employed a quasi-experimental strategy. Port Harcourt, found in Rivers State, is positioned within the South-South geo-political region. Nigeria is situated in the West Africa region. A total of 2,150 Senior Secondary three Biology students make up the population, from which a sample of 120 individuals was selected from intact classes in chosen schools. The investigation was guided by three research enquiries and three proposed hypotheses. The team employed a Biology Achievement Test as the tool for data collection. The selected test items were derived from standardised questions used in prior Senior School Certificate assessments. The West African Examinations Council received validation from two professors with expertise in Science Education and one professor with a focus on Measurement and Evaluation. The reliability coefficient was determined through the test-retest strategy, specifically utilising the Pearson Product Moment Correlation Coefficient, resulting in a value of 0.78. The analysis of the data included calculating the mean, standard deviation, and conducting a t-test, all at a significance level of 0.05. The findings of the study revealed a significant difference in academic performance between students who received instruction in Biology through a cooperative learning strategy and those who were educated using traditional lecture strategies. The students in the experimental group, instructed through the cooperative learning strategy, demonstrated significantly superior scores on the Biology achievement test in comparison to their counterparts in the lecture strategy group. No significant difference in achievement was observed between males and females. Determine whether the school is classified as public or private. In conclusion, the cooperative learning strategy demonstrates greater effectiveness in instruction and enhances the academic performance of Biology students when compared to the traditional lecture strategy[93].

This study sought to examine the effects of implementing a cooperative learning strategy on the average achievement scores of secondary school students in Biology. A Solomon four-group design was utilised, focussing on a target population of 183 form two students from four secondary schools. The experimental groups were instructed on a specific Biology topic over a duration of five weeks, employing a cooperative learning strategy. The control groups received instruction through the conventional teaching strategy. A pre-test was administered before the treatment, and a post-test was conducted after the treatment was completed. A Biology Achievement exam was conducted to evaluate the academic performance of students. The pilot testing phase revealed that the exam achieved a reliability coefficient of 0.84, derived from a sample size of 59 students. The analysis involved the application of t-tests, ANOVA, and ANCOVA strategies. Hypotheses were evaluated for acceptance or rejection according to a significance threshold of $P \leq 0.05$. The adoption of a cooperative learning strategy resulted in a significant rise in average achievement scores in contrast to the conventional teaching strategy. Additionally, it was demonstrated that gender did not significantly influence academic achievement. The findings indicate that implementing cooperative learning is an exceptionally effective instructional strategy that warrants promotion among Biology educators[94].

The research examines the perspectives of online students on group work, their collaborative processes, and the skills they developed through the case study strategy. The investigation utilised a mixed-strategys strategy, combining both collective and individual assessments, in addition to survey evaluation and qualitative data analysis derived from a questionnaire. The analysis revealed that the average score for the group assignment surpasses that of the individual assignment, while the individual assignment shows a broader distribution of scores. Male students who opt for collaboration in a group generally attain higher group marks than their individual scores, suggesting that they gain advantages from working together. Students collectively acknowledged the importance of collaborative efforts as an essential skill for their future careers. They recognised that participating in collaborative efforts enhanced their understanding by utilising the insights and skills of their peers. Working in a group requires considerable time and effort; however, students will develop the necessary skills to gain essential knowledge and address the assigned problem. Students recognised several supplementary skills that they felt were developed through their participation in collaborative projects. The skills included effective communication, attentive listening, persuasive negotiation, thorough research, and problem-solving. Engagement in collaborative endeavours greatly enhanced these abilities. The results demonstrate that effective group collaboration can be achieved and managed in an online setting, although it necessitates meticulous consideration of the logistical and technological challenges that may emerge. While not all students may fully accept it, group work as a form of cooperative learning can equip them with essential skills for their future careers, where collaboration will be crucial[95].

The investigation into cooperative learning (CL) is robust and dependable. While CL presents considerable benefits in empirical studies, its incorporation into teacher education programs faces several challenges. Teacher educators show hesitation in embracing collaborative learning (CL) and tend to stick with the conventional frontal teaching strategy. The difficulties encountered by those who educate teachers in implementing CL could explain this situation. A concurrent triangulation mixed strategy study design was employed to investigate the perceived difficulties in implementing cooperative learning among teacher educators from India. A questionnaire was distributed, resulting in the collection of 300 responses from teacher educators through a survey. Following that, a semi-structured interview was carried out with eight participants from the survey. The findings reveal that teacher educators identify approximately 63% of challenges stemming from issues related to teachers, learners, the curriculum syllabus, and administrative obstacles. Female teacher educators faced more significant challenges than their male counterparts. The ANOVA analysis revealed a notable difference in the challenges faced across various age groups. The findings underscore the importance of conducting future studies to meticulously explore the challenges associated with implementing CL in larger and more diverse samples across various educational contexts worldwide, aiming to develop effective solutions[96].

This study sought to evaluate the varying effects of personalised and collaborative video-based instructional strategyes on the academic performance of high school students in Biology within Makurdi Metropolis, Benue State, Nigeria. Three enquiries were formulated, leading to the generation of three hypotheses that were then rigorously examined. The investigation employed a quasi-experimental framework characterised by a non-randomized pretest-posttest control group strategy. The population for this study includes 1,907 individuals, with a sample of 84 SS1 students selected from two secondary schools through a multistage sampling strategy. In each school, whole classes were randomly assigned to either an individualised video-based instructional strategy or a collaborative video-based instructional strategy. The Biology Achievement Test (BAT) was developed, validated by a panel of five experts, piloted, and then utilised for the study. The reliability of BAT was assessed through the Kuder-Richardson formula 21 (K-R21), yielding a value of 0.68. The study's issues were tackled through the application of mean and standard deviation, with hypotheses being evaluated via Analysis of Covariance (ANCOVA) at a significance threshold of 0.05. The results demonstrate that tailored and cooperative video-based teaching strategies effectively improve student performance in ecology. Nonetheless, the use of a collaborative video-based teaching strategy demonstrates greater effectiveness than a personalised video-based instructional strategy. A statistically significant difference exists in the mean scores of male and female students when taught ecological concepts through individualised and cooperative video-based instructional strategies. The findings indicate a preference for the cooperative video-based instructional strategy. Consequently, it is recommended that secondary school Biology educators implement a cooperative video-based instructional strategy in their teaching of the subject[97].

The investigation explored the effects of the numbered heads together cooperative instructional strategy (NHT) on the degree of interest in Biology among secondary school students in the Awka Education Zone. The investigation was guided by two research questions and three null hypotheses, evaluated at a significance level of 0.05. The investigation employed a quasi-experimental strategy, specifically implementing a pretest posttest non-randomized control group within a 2x2 factorial research design. The sample comprised 4,755 individuals enrolled in their second year of senior secondary education (SS2). A multi-stage sampling process was employed to select a sample size of 64 SS2 students, comprising 21 males and 43 females. The participants chosen for the investigation were organised into two intact groups. Participants were subsequently assigned at random to either the experimental group, which included 23 females and 10 males, or the control group, comprising 20 females and 11 males, determined by a coin flip. The process of data collection utilised a Biology students interest scale (BSIS) comprising 20 items and five response alternatives, developed by the team. The interest scale for Biology students was validated by three experts, and its reliability was demonstrated with a Cronbach's alpha coefficient of 0.77. The group of students participating in the experiment was taught selected Biology concepts through the NHT strategy, whereas the control group was instructed in the same topics using the Conventional Lecture Strategy (CLM). The study's issues were tackled through the application of mean and standard deviation, with null hypotheses being evaluated via Analysis of Covariance (ANCOVA) at a significance threshold of 0.05. The findings of the study demonstrate that NHT outperforms CLM in fostering students' interest in Biology. The influence of gender on students' interest in Biology was minimal. Additionally, the analysis revealed no notable correlation between teaching strategies and gender concerning students' interest in Biology. The study concluded that NHT is an inclusive strategy that boosts student engagement in Biology by fostering collaborative group work and individual accountability within the team. The findings indicate that Biology educators in schools ought to adopt NHT (Next-Generation Teaching) to boost student engagement in the subject of Biology[98].

2.4 Conceptual Model

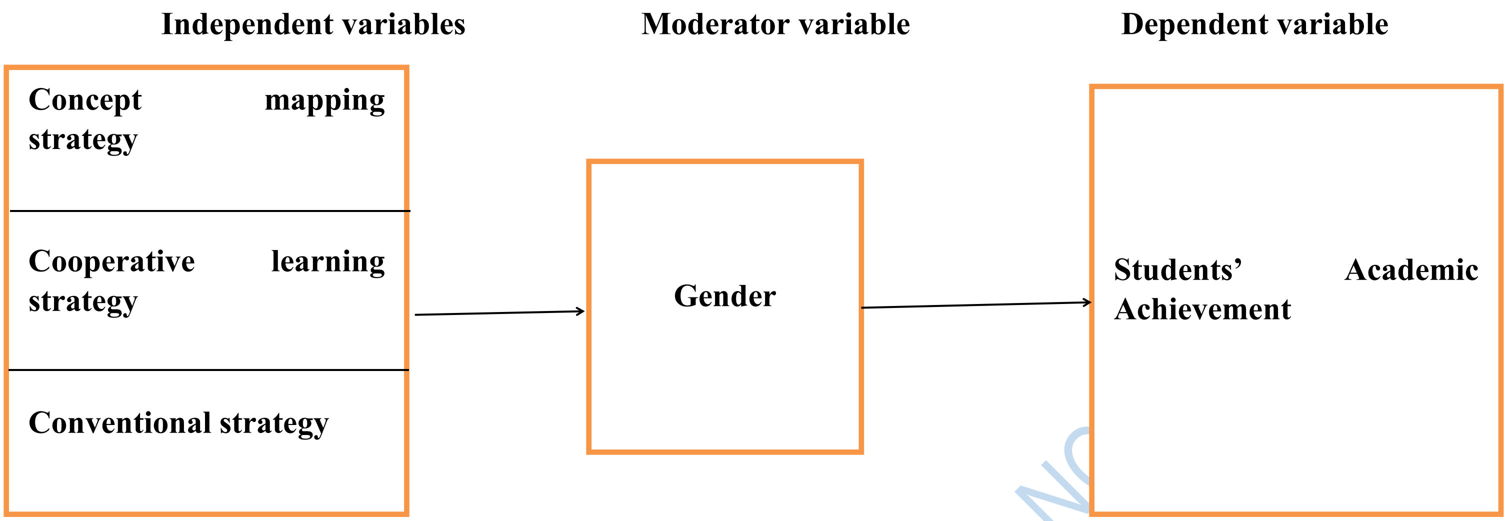

Fig 2.1: Developed by Researcher, 2025

Source: 1

The conceptual model depicts how the different variables interact with one another. There is a connection between the dependent variable, mediating variable and the two independent variables. The effect that the independent factors have on the Biology students achievement, which is the dependent variables, will investigate the connections. It is expected that if the strategies are used effectively, they will add to good teaching and high attainment of academic achievement among Biology students.

2.5 Summary of Gap in Literature Reviewed

Concept maps serve as visual tools for organising and illustrating knowledge, as evidenced by this review. Concept maps enable a structured arrangement of ideas, placing the broadest and most general concepts at the top, while the more specific and narrower concepts are arranged beneath them. The literature highlights that concept maps and cooperative learning serve multiple purposes in the classroom, encompassing teaching and learning, evaluation, curriculum design, and the documentation and preservation of expert knowledge. Concept mapping is extensively employed in educational environments as a strategy for facilitating teaching and learning.

Cooperative learning is an instructional strategy that engages students in group-based learning activities, emphasising the importance of healthy interactions among participants. This strategy involves small groups of students with different skill levels engaging in educational activities to improve their understanding of a specific topic. The participation of each student within the group and the cooperation among group members is considered important. The contributions of the students are recognised and rewarded for both their personal and group efforts. The cooperative learning technique has been noted to enhance active listening, foster participation, and cultivate empathy by designating each group member a vital role in the academic task. Collaboration among group members is crucial for collectively reaching a shared goal, as each individual depends on the input of their colleagues.

Novak was at the forefront of developing concept mapping and cooperative learning at Cornwall University during the 1970s. The teaching strategys outlined here draw upon cognitive learning principles, specifically Ausubel's theory of meaningful verbal learning and the tenets of constructivism. The existing literature provides empirical evidence indicating that concept mapping and cooperative learning yield superior outcomes in Biology, with groups utilising concept mapping often exhibiting a marginal advantage in various situations. Additionally, there were no notable differences in the academic performance of males and females in Biology, indicating that this instructional strategy effectively educates both genders in the classroom. A significant number of students expressed a positive view on concept mapping and cooperative learning, recognising that it improved the structure of their knowledge. Nonetheless, the findings indicated that the implementation of concept mapping and cooperative learning failed to significantly reduce the anxiety levels encountered by female students within the realm of science. Moreover, students have indicated that creating a concept map requires a significant investment of time.

The use of concept mapping and cooperative learning techniques has been confirmed to promote meaningful learning more effectively than rote learning. The participants in the concept mapping and cooperative learning groups demonstrated enhanced comprehension and application skills relative to those instructed through traditional strategies. This study utilised concept mapping and cooperative learning strategies, which are both effective and innovative. It is important to highlight that these strategies are not commonly adopted in Nigerian schools, unlike their significant application in Western countries. Ultimately, the literature suggests that the conventional strategy centres on the instructor and encourages rote memorisation devoid of comprehension. Further studies indicate that children exposed to conventional teaching strategies generally attain lower academic performance than their counterparts who experience different instructional strategies.

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Chapter Three

Methodology

This chapter focuses on the procedure that will be used in this study. It will involve the Research Design; Population of the Study; Sample and Sampling Technique; Description of Research Instruments; Validity of Research Instruments; Reliability of Research Instrument; Data Collection, Data Analysis and Ethical Approval.

3.1 Research Design

The study employed a 3x2 factorial quasi-experimental design, incorporating pretest-posttest measures, along with non-randomized control and non-equivalent intact groups. The study emphasises concept mapping strategy, cooperative learning strategy, and conventional strategy across three levels, including two treatment groups and a control group. Concept mapping strategies and the cooperative learning strategy functioned as independent variables, serving as the treatment group for the experimental groups, while the conventional teaching strategy was employed for the control group. The dependent variable was the achievement of pre-service teachers. Gender served as the moderator variable, also divided into two levels: male and female.

Table 3.1 Research Design Layout

Group	Pre-test	Treatment	Post-test	Gender
E_1	Q_1	X_1	Q_4	M/F
E_2	Q_2	X_2	Q_5	M/F
E_3	Q_3		Q_6	M/F

E_1 – Experimental 1 for Concept mapping strategy

E_2 – Experimental 2 for Cooperative learning strategy

E_3- Conventional Strategy

Q_1- Pre-test for treatment group 1

Q_2 - Pre-test for treatment group 2

Q_3- Pre-test for control group

Q_4- Post-test for treatment group 1

Q_5 - Post-test for treatment group 2

Q6 - Post-test for control group

X_1 - Treatment1

X_2 - Treatment 2

M1 – Male 1 for Concept mapping strategy

F_1 – Female 1 for Concept mapping strategy

M_2 - Male 2 for Cooperative learning strategy

F_2- Female 2 for Cooperative learning strategy

M_3- Male 3 for Conventional Strategy

F_3- Female 3 for Conventional Strategy

H_1- High 1 achievement for Concept mapping strategy

L_1- Low 1 achievement for Concept mapping strategy

H_2- High 2 achievement for Cooperative learning strategy

L_2- Low 2 achievement for Cooperative learning strategy

H_3- High 3 achievement for Conventional Strategy

L_3-Low 3 achievement for Conventional Strategy

3.2 Population of the Study

The population for the study comprises of all the 100 Level Biology students in Federal Colleges of Education Southwest, Nigeria which include Federal College of Education (Special)

Oyo, Oyo State, Federal College of Education Abeokuta Osele Ogun State and Federal College of Education Iwo, Osun State. The population of 100 level Biology students in Federal College of Education (Special) Oyo were 117 Students while the total population of Biology students at Federal College of Education Osele were Abeokuta 115 Students and the total population of Biology students at Federal College of Education Iwo were 123. The total target populations for the study were 355 Biology students of the schools in consideration as at the time of conducting this study as shown in the Table 3.2.

Table 3.2 Population of the Study

Federal College of Education (Special) Oyo	Federal College of Education Abeokuta Ogun State	Federal College of Education Iwo Osun State	Total Population
117	115	123	355

3.3 Sample and Sampling Techniques

A multi-stage sampling procedure was utilised to select the participants for the study. The initial phase entails employing a simple random sampling technique to select three Federal Colleges of Education that fulfil the criteria of possessing qualified lecturers and accessible teaching and learning facilities relevant to the topic at hand.

Secondly, the study comprised three intact classes of 100 level Biology students, which will be randomly selected from three different schools according to the established selection criteria. One school was designated as the control group while two schools were assigned as experimental groups (E1 and E2). The two experimental groups, E1 and E2, underwent concept mapping and cooperative learning strategies, respectively, while the control group, E3, experienced the conventional strategy.

3.4 Research Instruments

This study utilised four research instruments, including the Cell Biology Achievement Test (CBAT) and a lesson plan format for concept mapping for the first experimental group, a cooperative learning strategy for the second experimental group, and a lesson plan format for the conventional strategy for the third experimental group. These tools were designed to facilitate the teaching of Cell Biology, which is central to the study.

3.4.1 Description of Research Instruments

Cell Biology Achievement test (CBAT)

Cell Biology Achievement test (CBAT). The achievement test was developed by the research in order to assess the level of achievement in Cell concepts. It covered the main topic of Biology taught with part1 students. It initially consists of 50 items multiple choice questions with five options A to E and based on six cognitive levels, Knowledge, comprehension, Application. Cell Biology Achievement Test (CBAT) answered by the Biology students it has two sections. Sections A consist of demographic Data which include Gender, Level, Name of the institution, Age. While section B initially comprises of 50 multiple choice questions with option A-E which was self-structured to test the student's achievement in cell topics in Biology. Find below table of specification for CBAT.

Table 3.4.1 Table of Specification

Content	Time spent on topic	% of the time spent on objectives	No of test item	Knowledge	Comprehension	application

			5			
Cell and concept and cell theory	30	26%	1	5(1,12)	4(18,20)	3(14,16,)
Protoplasm and its properties	45	39%	2	6(9,10,)	6(3,4,8)	1(5,6,7)
Cell division	40	35%	2	5(15,19)	2(2,11)	2(13,17)
Total	115	100%	5	16	12	6

Experimental Group 1 (Concept mapping strategy)

- Research assistants Identify and list the key concepts and terms relevant to the cell biology
- Research assistants provide an overview of the topic, ensuring students understand the key concepts that were included in the map.
- Students were asked to brainstorm and list related sub-concepts and terms for each key concept.
- Research assistant encouraged them to think about how these sub-concepts are related to the key concepts and to each other.
- Research assistants start the concept map with the central concept (sCell Biology) in the center of the map. And have students place the key concepts around the central concept.
- Students added sub-concepts around each key concept, linking them with lines.

- Students were instructed to add further details and hierarchies, creating more branches as needed and emphasise was made on the importance of showing connections and relationships clearly.

Experimental Group II (Cooperative Learning Strategy)

- Students were divided into small groups
- Students were assigned specific roles within each group, such as facilitator, recorder, timekeeper, and presenter.
- Relevant resources were given to students, including textbooks, articles, and multimedia materials, to aid group discussions and research.
- The research assistants facilitate discussions by offering guidance, answering questions, and ensuring that discussions stay on track.
- Encourage students to teach concepts to each other within their groups, reinforcing their own understanding and promoting peer learning.
- Each groups present their findings or solutions to the class.
- Individual and group achievement through various strategy, such as quizzes, presentations, and group reports were assessed in order to ensure accountability and understanding.

Experimental Group III (Conventional strategy)

- A detailed lesson plan was developed by outlining the key topics, objectives, and activities for the cell biology lesson.
- Start with an engaging introduction to capture students' interest and provide an overview of what will be covered in the lesson, highlighting the importance and relevance of cell biology.

- Delivered a structured lecture on the topic, using clear and concise language.
- Break down complex topics into manageable sections and explain each key concept thoroughly, providing examples and analogies to aid understanding.
- Engage students by asking questions throughout the lecture to check their understanding.
- Use various assessment strategy to evaluate student understanding tests

3.5 Validity of Cell Biology Achievement Test (CBAT)

The validation of the research instruments was conducted by the supervisor and three lecturers from the Department of Science Education at Lead City University, Ibadan, Nigeria. The BAT was initially constructed with 50 objective questions and underwent expert review to ensure its legitimacy regarding face, content, and construct validity. All corrections and suggestions were implemented prior to the production of the final draft.

3.6 Reliability of Cell Biology Achievement Test (CBAT)

A preliminary study was carried out to assess the reliability of the primary research tool, the Cell Biology Achievement Test (CBAT). The research tools were applied to a subset of the population that was not involved in the primary study. The reliability value of the instruments was determined using the Kuder Richardson (KR-20) formula. The result obtained was 0.75 while the discriminating index and difficulty index is 0.30 and 0.20, respectively.

3.7 Method of Data Collection

Prior to administering the instruments to the chosen students, a letter of introduction was secured from the Head of Department (HOD), Science Education, Lead City University Ibadan, and sent to the Heads of the selected schools. The approval of the Lecturer and the collaboration of the chosen students were also being requested prior to the implementation of the instruments. The study was conducted over a duration of 10 weeks, with the initial week dedicated to visiting schools. One week was allocated for the training of research assistants. The pre-test was administered to all groups over a period of two weeks, followed by a six-week treatment phase for the treatment group, and finally, the post-test was conducted in the last week. The team and the assistants waited for all the participating students to complete the achievement test before collecting.

3.7.1 Work Schedule Table for Data Collection

Work Schedule for data collection was divided into five stages; Visitation stage, Training of research assistant stage, pre-treatment stage, treatment stage and post treatment stage as shown in the diagram:

Week	Week Spend	Description
1 week	1 week	Visitation to schools

2 week	1 week	Training of Research Assistance
3 week	1weeks	Administration of pre-test instrument • Achievement test
4 to 9 week	6weeks	Treatments • Experimental Groups • Experimental Groups
10 week	1 week	Administration of Posttest Instruments; • Achievement test
Total week	**10weeks**	

3.8 Method of Data Analysis

The hypotheses formulated for the study were tested using analysis of covariance at 0.05 level of significance.

3.9 Ethical Approval

Ethical approval to carry out the study was obtained from the relevant authorities' right from the Head of Department of Science Education, Lead City University, Ibadan, and Head of Department (Biology) in the three selected Federal Colleges of Education.

Chapter Four

Results and Discussion of Findings

This chapter presents results of the analyses and discussion of findings. The results and discussion of findings are presented based on demographic data analysis of the participants and hypotheses as follow:

4.1 Demographic Data Analysis

This section examines and presents information about the demographic data analysis of students based on gender.

Table 4.1.2: Distribution of the Participants by Gender

Gender	Frequency	Percent	Cumulative Percent
Male	154	43.4	43.4
Female	201	56.6	100.0
Total	355	100.0	

Source: Field Survey, 2024

Table 4.1 revealed that 154 (43.4%) of the participants were males, while 201 (56.6%) were females. This means that most of the participants were females.

Table 4.1.3: Distribution of the Participants by Groups

Group	Frequency	Percent	Cumulative Percent
Control	123	34.6	34.6
Concept Mapping	117	33.0	67.6
Cooperative learning	115	32.4	100.0
Total	355	100.0	

Source: Field Survey, 2024

Table 4.4 revealed that 123 (34.6%) of the participants were exposed to conventional strategy of teaching as controlled group, 117 (33.0%) were exposed to concept mapping while 115 (32.4%) were exposed to cooperative learning.

4.2 Test of Hypotheses

This section answered the test of hypothesis

H_01: There will be no significant main effect of concept mapping strategy on Biology students' academic achievement when taught Cell Biology.

Table 4.2.1a: Shows the analysis of covariance of main effect of concept mapping on Biology students' academic achievement when taught Cell Biology.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4561.001[a]	2	2280.500	33.884	.000	.222
Intercept	1932.749	1	1932.749	28.717	.000	.108
Pre-Test	341.127	1	341.127	5.068	.025	.021
Concept Mapping	1984.441	1	1984.441	29.485*	.000	.111
Error	15950.983	237	67.304			
Total	126436.000	240				
Corrected Total	20511.983	239				

a. R Squared = .222 (Adjusted R Squared = .216) * denoted significant @ $p \leq 0.05$

Source: Field Survey, 2024

Table 4.2.1a showed a significant main effect of concept mapping on Biology students' academic achievement when taught Cell Biology ($F_{(1;237)}$=29.485 with associated probability (p=0.000) whereby the probability value of 0.000 is less than 0.05 ($p<0.05$) level of significant. While Partial Eta Squared value of 0.111 showed the contributing effect size of 11.1%. The null hypothesis is therefore rejected. This implied that the introduction of concept mapping as a strategy significantly affected the academic achievement of Biology students when taught Cell Biology.

Table 4.2.1b: Estimated Marginal Means of Concept Mapping on Biology students' academic achievement when taught Cell Biology

Group	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound

Control	17.670[a]	.811	16.071	19.268
Concept Mapping	24.518[a]	.836	22.872	26.164

Table 4.2.1b shows that participants exposed to concept mapping (treatment group 1) had higher posttest mean ($\bar{x}$) score of 24.518 on Biology students' academic achievement when taught Cell Biology, than other participants in the control group with posttest mean ($\bar{x}$) score of 17.670. This means that participants exposed to Concept Mapping strategy of teaching (treatment group 1) performed better than those in the control group, the difference is sufficient to justify the effectiveness of concept mapping over conventional strategy of teaching cell.

$H_0$2: There will be no significant main effect of cooperative learning on Biology students' academic achievement when taught Cell Biology

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Table 4.2.2a Analysis of covariance of main effect of cooperative learning on Biology students' academic achievement when taught Cell Biology.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4032.837[a]	2	2016.418	29.427	.000	.200
Intercept	1252.154	1	1252.154	18.274	.000	.072
Pre-Test	349.317	1	349.317	5.098	.025.	.021
Cooperative Learning	754.514	1	754.514	11.011*	.	. 045
Error	16102.861	235	68.523		001	
Total	122340.000	238				
Corrected Total	20135.697	237				

a. R Squared = .200 (Adjusted R Squared = .193) * denoted significant @ $p \leq 0.05$

Source: Field Survey, 2024

Table 4.2.2a revealed a significant main effect of cooperative learning on Biology students' academic achievement when taught Cell Biology ($F_{(1;235)}$=11.011 with associated probability (p=0.001) whereby the probability value of 0.001 is less than 0.05 (p<0.05) level of significant. The Partial Eta Squared value of 0.045 accounting for 4.5%. The null hypothesis is therefore rejected. This implied that use of cooperative learning as a strategy independently and significantly affect the academic achievement of Biology students when taught Cell Biology.

Table 4.2.2b: Estimated Marginal Means of Cooperative Learning on Biology students' academic achievement when taught Cell Biology

Group	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Control	17.670[a]	.811	16.071	19.268
Cooperative learning	23.436[a]	.978	21.509	25.362

Source: Field Survey, 2024

Table 4.2.2b revealed that participants exposed to cooperative learning (treatment group 2) had higher posttest mean ($\bar{x}$) score of 23.436 on Biology students' academic achievement when taught Cell Biology, than other participants in the control group with posttest mean ($\bar{x}$) score of 17.670. This means that participants exposed to Cooperative learning strategy of teaching (treatment group 2) performed better than those in the control group, the difference is sufficient to justify the effect cooperative learning on the academic achievement of Biology students while taught cell biology compared with Conventional strategy of teaching in Federal College of Education in Southwest Nigeria.

$H_0$3: There will be no significant main effect of gender on biology students' academic achievement when taught Cell Biology.

Table 4.2.3a Analysis of covariance of main effect of Gender on Biology students' academic achievement when taught Cell Biology.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared

Corrected Model	3542.314[a]	2	1771.157	33.384	.000	.159
Intercept	1663.152	1	1663.152	31.348	.000	.082
Pre_Test	2825.557	1	2825.557	53.257	.000	.131
Gender	367.977	1	367.977	6.936	.009*	.019
Error	18675.280	352	53.055			
Total	197709.000	355				
Corrected Total	22217.594	354				

a. R Squared = .159 (Adjusted R Squared = .155) * denoted significant @ $p \leq 0.05$
Source: Field Survey, 2024

Table 4.2.3a indicate that there is a significant difference on the main effect of Gender on Biology students' academic achievement when taught Cell Biology at Federal College of Education in Southwest Nigeria ($F_{(1;352)}$=6.936 with associated probability (p=0.009) whereby the probability value of 0.000 is less than 0.05 ($p<0.05$) level of significant while Partial Eta Squared value of 0.019 showed the contributing effect size of only 1.9%. Therefore the null hypothesis is rejected. This implied that gender as a factor affect the academic achievement of Biology students when taught Cell Biology.

Table 4.2.3b: Estimated Marginal Means of Gender on Biology students' academic achievement when taught Cell Biology

			95% Confidence Interval	
Gender	Mean	Std. Error	Lower Bound	Upper Bound
Female	23.408[a]	.590	22.247	24.569
Male	21.334[a]	.516	20.319	22.349

Table 4.2.3b indicated that the female participants had higher posttest mean ($\bar{x}$) score of 23.408 than that of their male counterparts had posttest mean ($\bar{x}$) score of 21.334. This means female had higher mean average score than the males after considering other factors, gender is also a key factor that significantly affects the academic achievement of biology students taught cell Biology.

H_04: There will be no significant interaction effect of concept mapping strategy and gender on Biology students' academic achievement when taught Cell Biology.

Table 4.2.4a Analysis of covariance of interactive effect of concept mapping strategy and gender on Biology students' academic achievement when taught Cell Biology.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	5784.362[a]	4	1446.090	23.074	.000	.282
Intercept	2576.894	1	2576.894	41.118	.000	.149
Pre-Test	97.970	1	97.970	1.563	.212	.007
Gender	552.324	1	552.324	8.813	.003	.036
Concept Mapping	2080.674	1	2080.674	33.200	.000	.124
Gender * Concept Mapping	673.304	1	673.304	10.744	.001*	.044
Error	14727.621	235	62.671			
Total	126436.000	240				
Corrected Total	20511.983	239				

a. R Squared = .282 (Adjusted R Squared = .270) * denoted significant @ $p \leq 0.05$
Source: Field Survey, 2024

Table 4.2.4a showed a significant interaction effect of gender and concept mapping on Biology students' academic achievement when taught Cell Biology ($F_{(1;\ 235)}$=10.744 with associated probability (p=0.001) whereby the probability value of 0.001 is less than 0.05 ($p<0.05$) level of significant while Partial Eta Squared value of 0.044 showed the contributing effect size of only 4.4%. The null hypothesis was therefore rejected. This implied that the introduction of concept mapping strategy with great consideration of the students' gender significantly affect the academic achievement of Biology students when taught Cell Biology.

Table 4.2.4b: Estimated Marginal Means of concept mapping and gender on Biology students' academic achievement when taught Cell Biology

Gender	Group	Mean	Std. Error	95% Confidence Interval

				Lower Bound	Upper Bound
Female	Control	21.056[a]	1.096	18.897	23.214
	Concept Mapping	24.732[a]	1.179	22.410	27.055
Male	Control	14.517[a]	1.062	12.425	16.609
	Concept Mapping	24.981[a]	1.023	22.967	26.996

Table 4.2.4b showed that for the female participants there is a little difference in the average mean ($\bar{x}$) score between control group ($\bar{x}$) = 21.056 and Concept Mapping (treatment 1) group ($\bar{x}$) = 24.981, while the male participants had a clear average mean difference between the control group ($\bar{x}$) = 14.360 and Concept Mapping strategy(treatment 1) group ($\bar{x}$) = 24.981.Although, the effect of concept mapping strategy was evident on both gender, it is obvious that concept mapping strategy had a clear influence/effect on the male as there is an obvious difference between the control group and treatment group of concept mapping strategy. Hence, it could be deduced that concept mapping had a great effect/impact on the male than on the female' academic achievement of Biology students taught cell Biology.

H_05: There will be no significant interactive effect of cooperative learning and gender on Biology students' teachers' academic achievement when taught Cell Biology.

Table 4.2.5a Analysis of covariance of interaction effect of cooperative learning and gender on Biology students' teachers' academic achievement when taught Cell Biology

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	5285.146[a]	4	1321.286	20.731	.000	.262
Intercept	1897.784	1	1897.784	29.776	.000	.113
Pre_Test	83.285	1	83.285	1.307	.254	.006
Cooperative Learning	1022.494	1	1022.494	16.043	.000	.064
Gender	851.980	1	851.980	13.367	.000	.054
Cooperative Learning * Gender	395.528	1	395.528	6.206*	.013	.026
Error	14850.551	233	63.736			
Total	122340.000	238				
Corrected Total	20135.697	237				

a. R Squared = .262 (Adjusted R Squared = .250) * denoted significant @ $p \leq 0.05$
Source: Field Survey, 2024

Table 4.2.5a revealed that there is a significant interaction effect of gender and cooperative learning on Biology students' academic achievement when taught Cell Biology ($F_{(1, 233)}$=6.206 with associated probability (p=0.013) whereby the probability value of 0.013 is less than 0.05 (p<0.05) level of significant while Partial Eta Squared value of 0.26 showed the contributing effect size of 2.6%.. The null hypothesis was therefore rejected. This implied that the introduction of cooperative learning strategy with great consideration on the students' gender significantly affect the academic achievement of Biology students when taught Cell Biology.

Table 4.2.5b: Estimated Marginal Means of cooperative learning strategy and gender on Biology students' academic achievement when taught Cell Biology

Group	Gender	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Control	Female	21.056[a]	1.096	18.897	23.214
	Male	14.517[a]	1.062	12.425	16.609
Cooperative learning	Female	24.840[a]	1.308	22.264	27.417
	Male	23.563[a]	1.135	21.326	25.799

Table 4.2.5b indicated that for the female participants there is a difference in the average mean ($\bar{x}$) score between control group ($\bar{x}$) = 21.056 and Cooperative learning strategy (treatment 2) group ($\bar{x}$) = 24.840 while the male participants had a clear positive average mean difference between the control group ($\bar{x}$) = 14.517 and Cooperative learning strategy (treatment 2) group ($\bar{x}$) = 23.563. Although, the female had higher mean score, it is obvious that cooperative learning strategy had a clear influence/effect on the male as there is an obvious difference between the control group and treatment group of cooperative learning strategy. Hence, it could be deduced that cooperative learning strategy had a great effect/impact on the male than on the female academic achievement of Biology students taught cell Biology.

4.3 Discussion of Findings

According to the initial hypothesis, the results indicated that the introduction of concept mapping as a strategy significantly affect the academic achievement of Biology students when taught Cell Biology at Federal College of Education in Southwest Nigeria because the p value of 0.000 is less than 0.05 ($p<0.05$) level of significant which means that the null hypothesis is rejected. Also the Estimated Marginal Mean shows that participants exposed to Concept Mapping strategy of teaching (treatment group 1) performed better than those in the control group. The finding aligns with a previous study conducted in Enugu Education Zone using a multistage selection strategy. The outcome of the study indicated that Students who were instructed in Biology through the utilization of concept mapping exhibited superior achievement compared to their peers who were taught utilizing the lecture technique[1]. Also, the study investigates the impact of concept maps on the academic achievement of higher secondary level school Students in the field of Biology in Colleges from Gadhinglaj Taluka shows that the concept map technique employed for teaching Biology proved to be helpful for Students at the higher secondary level[2]. Another study conducted in four Government schools in Ludhiana city revealed that the group instructed through the use of Concept mapping exhibited significantly higher levels of accomplishment in Chemistry compared to the group taught using the Conventional technique[3]. The finding is also in line with the study carried out in Senior Secondary Schools in Ekiti State revealed that the use of Concept Mapping Instructional strategy positively impacted learning achievement in physics[4]. Also a study conducted at senior secondary schools in Minna Metropolis, the research findings support the view that the substantial disparity in the average achievement scores between low-achieving Biology Students who were instructed through the utilisation of concept maps and those who were taught using the traditional lecture strategy[5].

The finding from the hypothesis two reviewed that there is a significant main effect of cooperative learning strategy on Biology students' academic achievement when taught Cell Biology at Federal College of Education in Southwest Nigeria whereby the p value of 0.000 is less than 0.05 ($p<0.05$) level of significant. The null hypothesis there will be no significant main effect of cooperative learning on Biology students' academic achievement when taught Cell Biology at Federal College of Education in Southwest Nigeria was rejected, while the estimated marginal mean revealed that participants exposed to cooperative learning (treatment group 2) had higher posttest mean ($\bar{x}$) score of 23.436 on Biology students' academic achievement when taught Cell Biology, than other participants in the control group with posttest mean ($\bar{x}$) score of 17.670. This means that participants exposed to Cooperative learning strategy of teaching (treatment group 2) performed better than those in the control group, the difference is sufficient to justify the effect cooperative learning on the academic achievement of Biology students while taught cell biology compared with Conventional strategy of teaching in Federal College of Education in Southwest Nigeria. The above findings is in line with a study carried out in Ebonyi State, Nigeria revealed that the use of cooperative learning strategy surpasses the effectiveness of traditional learning strategy in promoting elevated academic achievement and long-term retention of knowledge[6]. While another study revealed that cooperative learning has a notable impact on the academic achievement of grade ten Students in acquiring and using scientific skills[7].

Furthermore findings from hypothesis three indicated that there is a significant difference on the main effect of Gender on Biology students' academic achievement when taught Cell Biology at Federal College of Education in Southwest Nigeria whereby the p value of 0.000 is less than 0.05 (p<0.05) level of significant. The null hypothesis there will be no significant main effect of gender on Biology students' academic achievement when taught Cell Biology at Federal College of Education in Southwest Nigeria was rejected, while the estimated marginal mean indicate that the female participants had higher posttest mean ($\bar{x}$) score of 23.408 than that of their male counterparts had posttest mean ($\bar{x}$) score of 21.334. This means females have higher mean average score than the males taught Cell Biology at Federal College of Education in Southwest Nigeria. The findings is not in line with study carried out in two senior secondary schools in Adamawa state that shows no notable disparity observed between male and female students in the experimental group[9]. A study carried out at Ika South Local Government Area, Delta State which revealed that an inequality was observed in the achievement of male and female students whereby female students exhibiting superior outcomes[17] while a study carried out at High School Students in Biology in Lagos, Nigeria revealed that gender did not have any influence on students achievement[10]. This present study is also in line with a previous study carried out in secondary schools in Nyamagabe area, Rwanda which revealed that females demonstrating significantly higher retention than males[10].

The result from the findings in hypothesis four indicated that there is a significant interaction effect of concept mapping strategy and gender on Biology students' academic achievement when taught Cell Biology at the Federal College of Education in Southwest Nigeria whereby the p value of 0.001 is less than 0.05 ($p<0.05$) level of significant. The null hypothesis there will be no significant interaction effect of concept mapping strategy and gender on Biology students' academic achievement when taught Cell Biology at Federal College of Education in Southwest Nigeria was rejected, while estimated marginal mean shows that for the female participants there is a little difference in the average mean ($\bar{x}$) score between control group ($\bar{x}$) = 21.056 and Concept Mapping strategy (treatment 1) group ($\bar{x}$) = 24.981 while the male participants had a clear average mean difference between the control group ($\bar{x}$) = 14.360 and Concept Mapping strategy (treatment 1) group ($\bar{x}$) = 24.981.Although, the effect of concept mapping strategy was evident on both gender. The present study is in line with the previous study which shows no notable disparity observed between male and female students in the experimental group[9].

While in another study it showed that no significant combined effect of teaching strategy, gender, and ability on the academic achievement of basic science students which does not support the present study because in the present study the hypothesis is significant[10]. Also a study carried out in Ika South Local Government Area, Delta State shows that inequality was observed in the achievement of male and female students who were instructed using the concept learning strategy, with female students exhibiting superior outcomes[13]. Another study carried out with High school students Biology in Lagos, Nigeria revealed that gender did not have any influence on students achievement[14]. While another study carried out among secondary schools in Nyamagabe area, Rwanda revealed that both male and female students who were taught via Concept mapping showed equal retention in photosynthesis[13]. Therefore, from both the present and previous study shows those researchers have different perspective on gender academic achievement.

Hypothesis five, the result of the findings revealed that there is a significant interaction effect of cooperative learning strategy and gender on Biology students' academic achievement when taught Cell Biology at Federal College of Education in Southwest Nigeria whereby the p value of 0.0013 is less than 0.05 ($p<0.05$) level of significant. The null hypothesis there will be no significant interactions effect of cooperative learning and gender on Biology students' academic achievement when taught Cell Biology at Federal College of Education in Southwest Nigeria was rejected while the estimated marginal mean indicates that for the female participants there is a little difference in the average mean ($\bar{x}$) score between control group ($\bar{x}$) = 21.056 and Cooperative learning (treatment 2) group ($\bar{x}$) = 24.840 while the male participants had a clear positive average mean difference between the control group ($\bar{x}$) = 14.517 and Cooperative learning (treatment 2) group ($\bar{x}$) = 23.563. Although, the females had higher average mean score, it is obvious that cooperative learning had a clear influence/effect on the males as there is an obvious difference between the control group and treatment group of cooperative learning.

Previous study carried out in Rivers State Nigeria shows that there was no discernible disparity in achievement between males and females which are not in line because the present study shows higher average mean score[15]. While in another study it shown that gender did not have a major impact on academic achievement which does not align with the present study[16]. However, a study conducted in Makurdi Metropolis, Benue State, Nigeria reveal that there is a statistically significant difference in the mean scores of male and female Students when taught ecological concepts using cooperative video-based instructional strategies which is in line with the present study while another study conducted at Awka Education Zone revealed that there was no significant relationship between teaching strategies and gender in relation to students interest in Biology which is not in line with the present study[17,18].

Endnotes

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Chapter Five

Conclusion

5.1 Summary of Findings

The study examined the effects of concept mapping and cooperative learning strategies on the academic performance of students in cell biology at Federal Colleges of Education in Southwest Nigeria. Seven hypotheses were assessed through ANCOVA to determine the significance of independent variables on dependent variables. The investigation utilised a 3x2 factorial quasi-experimental framework, integrating both pre-test and post-test assessments, and non-randomized control and non-equivalent intact groups. The investigation highlights the use of concept mapping strategy, cooperative learning strategy, and traditional strategies across three levels, which include two treatment groups and one control group. The treatment group for the experimental groups consisted of concept mapping strategies and cooperative learning strategies as independent variables, while the control group utilised the usual teaching strategy. The dependent variable was the performance of pre-service teachers, classified into two groups: high performers and low performers. The variable of gender acted as a moderating factor, categorised into two distinct levels: male and female. The study population includes all first-year Biology students from Federal Colleges of Education located in Southwest Nigeria, specifically at Federal College of Education (Special) Oyo, Oyo State, Federal College of Education Osiele Abeokuta, Ogun State, and Federal College of Education Iwo, Osun State. The total target population for the study consists of three hundred fifty-five (355) Biology students from the relevant schools during the period of this research. The results revealed a significant main effect of concept mapping on the academic performance of Biology students engaged in Cell Biology Eta Squared value of 0.111 signifies an effect size contribution of 11.1%. A significant main effect of cooperative learning strategy on the academic achievement of Biology students studying Cell Biology has been observed, as indicated by ($F_{(1,235)}$=11.011, p<0.05). The Partial Eta Squared value of 0.045 indicates that 4.5% of the variance is accounted for. A significant difference has been observed concerning the main influence of Gender on the academic performance of Biology students taught Cell Biology at the Federal College of Education in Southwest Nigeria ($F_{(1,352)}$=6.936 p<0.05). Furthermore, the Partial Eta Squared value of 0.019 suggests an effect size contribution of only 1.9%. There was a significant interaction effect of gender and concept mapping strategy on the academic achievement of students in Cell Biology ($F_{(1, 235)}$=10.744, p<0.05). The Partial Eta Squared value of 0.044 signifies an effect size contribution of 4.4%. There was a significant interaction effect of gender and cooperative learning strategy on the academic achievement of students in Cell Biology ($F_{(1, 233)}$=6.206, p<0.05). Furthermore, the Partial Eta Squared value of 0.026 signifies an effect size contribution of 2.6%.

5.2 Conclusion

Based on the findings, the study's findings indicate that concept mapping strategy and cooperative learning strategy have a significant positive impact on the academic achievement of Biology students in cell biology at Federal Colleges of Education in Southwest Nigeria. Both strategies demonstrated beneficial impacts on students' comprehension, with concept mapping strategy contributing 11.1% and cooperative learning representing 4.5% of the variance in achievement. Furthermore, gender served as a moderator factor affecting academic results, as male and female students exhibited different responses to the instructional strategies employed. The results suggest that employing alternative teaching strategies like concept mapping strategy and cooperative learning strategy can lead to improved learning outcomes in comparison to traditional strategies. Furthermore, the investigation uncovered notable interaction effects involving gender and the instructional strategies, in addition to the relationship between concept mapping and cooperative learning, on student achievement. The findings indicate that students' academic achievement in cell biology is enhanced by a blend of teaching strategies, especially when considering gender differences. The significant effect sizes from these interactions highlight the importance of incorporating a range of instructional strategies to address different learning requirements.

5.3 Recommendations

Based on the study's findings and objectives, the following recommendations are proposed:

1. Lecturers in Federal Colleges of Education in Southwest, Nigeria should incorporate concept mapping strategy into their cell biology curriculum to enhance students' academic achievement. This strategy can support students' comprehension and retention of complex biological concepts, as shown by its significant effect on learning outcomes.
2. Cooperative learning strategy should be embraced as an effective instructional strategy in cell biology, as it promotes student engagement, peer learning, and overall academic success. By working collaboratively, students may better understand and retain complex information.
3. Educators should be mindful of gender-specific learning needs and preferences when selecting instructional strategies. Given that gender has a significant effect on students' academic achievement, personalized strategies that accommodate gender differences can further improve learning outcomes.
4. Given the interaction effect of concept mapping strategy and gender, teachers should consider tailored applications of concept mapping that address the unique needs of male

and female students. This customization can further maximize the effectiveness of concept mapping for diverse student groups.

5. Cooperative learning groups should be structured with consideration of gender dynamics, encouraging inclusivity and balanced participation. This strategy can address the distinct learning styles of male and female students, fostering a supportive and productive learning atmosphere.

5.4 Contribution to Knowledge

It will serves as reference materials for other researchers in the area of effectiveness of concept mapping and cooperative learning strategies on Federal Colleges of Education students Academic Achievement in Cell Biology in Southwest Nigeria**.** it will also assist school administrators in understanding and to inspire and support the usage of concept mapping and cooperative learning strategies in the classroom.

5.5 Suggestion for Further Study

A similar research should be carryout on effectiveness of concept mapping and cooperative learning strategies among secondary school students Academic Achievement in Cell Biology in Southwest Nigeria**.**

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Appendix I

Lesson Plan on Cell Biology using Concept mapping Strategy.

Topic: cell and cell theory

Level: 100

Lesson note: week 1

Period: 1

Date: 8th July, 2024

Instructional Materials: A chart showing concept of a cell

Behavioural Objectives: By the end of the lesson, Students should be able to;

1. Define Cell.

2. Highlight the historical background of Cell concept

3. State the two types of Cell

Entry Behavior: Students are familiar with cell

Instructional Procedure

Step 1: The teacher presents the concept of cell as the basic, structural, functional and biological unit of all known living organism. Cell takes into consideration the chemical processes of life in relation to cell development from prokaryote to eukaryote cell. It is also the study of genetic component of cell with emphasis on DNA and RNA.

Step 2: The teacher goes further to highlight the historical background of Cell concept as: Cell was first described in 1665 by Robert Hooke, a scientist of great talent and versatility who was an accomplished technician and biologist. He designed one of the earliest optical microscopes with which he examined a thin section of cork and discovered that the cork contain a numerous box-like structures which we known to be cells.

Matthias Schleiden and Theodor Schwann a zoologist in the year 1838-1839 produced a cell theory which unified the ideas of the time by stating that the basic unit of structure and function in living organisms is the cell. Then the cell would seem to be a basic structural and functional unit of life of an organism.

Step 3: The teacher State the two types of Cell as Prokaryotic and eukaryotic cell

Prokaryotic cell are the first form of life on earth. They are simpler and smaller than eukaryotic cell and lack membrane bound organelles. Prokaryotic cell include two domain of the domain of life such as bacterial and archers while Eukaryotic cell are fifteen times wider than a typical prokaryote and can be as much as a thousand times greater in volume.

Evaluation: The teacher evaluates the Students using the following questions

1. Define Cell.

2. Highlight the historical background of Cell concept

3. State the two types of Cell

Conclusion/ summary: The teacher summaries the lesson by explaining and making corrections where necessary for the Students

Assignment: Draw a well label diagram of the plant and Animal cell

State at least ten (10) differences between plant and animal cells

Topic: cell

Sub-topic: Cytoplast and its Constituents

Level: 100

Lesson note: week 2

Period: 1

Date: 15 July, 2024

Duration:

Instructional Materials: A chart showing the concept map of cell organelles

Behavioural Objectives: By the end of the lesson, Students should be able to;

1. Explain the meaning of cytoplast.

2. list the cell organelles and functions.

Entry Behavior: The Students have been taught cell

Instructional Procedure: The teacher presents the topic with the following steps:

Step 1: The teacher presents the concept of cytoplast and its properties as the part of the cell that have different function that sustains the whole cell as the basic structural unit. The teacher mentions different examples of cell to include plant cell, animal cell and notes them on the board.

Step 2: Teacher goes further to mention the cell organelles by listing them on the board and stating at least one function of each of the cell organelles;

i. Nucleus**:** (i)control life activities of the cell (ii) Stores hereditary informationas it contains DNA
ii. Chromosomes: it contains DNA which stores genetic traits
iii. Mitochondria: it is the describe as the power house of the cell. They are sites of respiration or where energy is released from

iv. Vacuole**:** it contain cell saps that act as osmoregulator by helping to remove excess water in the cells

v. Nucleous**:** Produce ribosome for protein synthesis.

vi. Endoplasmic reticulum: it aids transport of materials within the cells

vii. Golgi bodies**:** function in synthesis, packaging and distribution of materials

viii. Chloroplast: contains chlorophyll that aid photosynthesis in green plant

ix. Lysosomes**:** they are sites for respiratory enzymes

x. Ribosomes**:** responsible for protein synthesis

xi. Cell wall: provides protection and shape for the cell

xii. Cell membrane**:** it serves a great role in selective absorption of materials

Evaluation:. The teacher evaluates the Students using the following questions

1. List at least two cell organelles
2. State at least three function of the cell organelles

Conclusion: The teacher summaries the lesson by explaining and making corrections where necessary for the Students.

Assignment: what is cell division and differentiates between mitosis and meiosis.

Topic: cell

Sub-topic: Mitosis

Level: 100

Lesson note: week 3

Period: 1

Date: 22 July, 2024

Duration:

Instructional Materials: A chart showing the concept map of cell division

Behavioural Objectives: By the end of the lesson, Students should be able to;

1. Mention types of cell division

2. Define Mitosis

3. List stages involve in mitosis cell division

Entry Behavior: The Students have been taught cell

Instructional Procedure: The teacher presents the topic with the following steps:

Step 1: The teacher state the types of cell division as mitosis and meiosis

Step 2: The teacher define mitosis as the process by which a cell nucleus divides to produce two daughter nuclei containing identical sets of chromosomes to the parent cells.

Step 3: The teacher list stages involve in mitosis cell division as interphase, prophase, metaphase, anaphase and telophase.

Evaluation:. The teacher evaluates the students using the following questions

1. Mention types of cell division

2. Define Mitosis

3. List stages involve in mitosis cell division

Conclusion: The teacher summaries the lesson by explaining and making corrections where necessary for the Students.

Assignment: explain the procedures involve in meosis cell division.

Appendix II

Lesson Plan on Cell Biology using Cooperative Learning Strategy.

Topic: cell and cell theory

Level: 100

Lesson note: week 1

Period: 1

Date: 29 July 2024

Instructional Materials: Chart

Behavioural Objectives: By the end of the lesson, Students should be able to;

1. Define Cell.

2. Highlight the historical background of Cell concept

3. State the two types of Cell

Entry Behavior: Students are familiar with cell

Instructional Procedure

Step 1: The teacher presents the concept of cell as the basic, structural, functional and biological unit of all known living organism. Cell takes into consideration the chemical processes of life in relation to cell development from prokaryote to eukaryote cell. It is also the study of genetic component of cell with emphasis on DNA and RNA.

Step 2: The teacher goes further to highlight the historical background of Cell concept as: Cell were first described in 1665 by Robert Hooke, a scientist of great talent and versatility who was an accomplished technician and biologist. He designed one of the earliest optical microscopes with which he examined a thin section of cork and discovered that the cork contain a numerous box-like structures which we known to be cells.

Matthias Schleiden and Theodor Schwann a zoologist in the year 1838-1839 produced a cell theory which unified the ideas of the time by stating that the basic unit of structure and function in living organisms is the cell. Then the cell would seem to be a basic structural and functional unit of life of an organism.

Step 3: The teacher State the two types of Cell as Prokaryotic and eukaryotic cell

Prokaryotic cell are the first form of life on earth. They are simpler and smaller than eukaryotic cell and lack membrane bound organelles. Prokaryotic cell include two domain of the domain of life such as bacterial and archers while Eukaryotic cell are fifteen times wider than a typical prokaryote and can be as much as a thousand times greater in volume.

Evaluation: The teacher evaluates the Students using the following questions

1. Define Cell.

2. Highlight the historical background of Cell concept

3. State the two types of Cell

Conclusion/ Summary: The teacher summaries the lesson by explaining and making corrections where necessary for the Students

Assignment: Draw a well label diagram of the plant and Animal cell

State at least ten (10) differences between plant and animal cells

Topic: cell

Sub-topic: Cytoplast and its Constituents

Level: 100

Lesson note: week 2

Period: 1

Date: 5 August, 2024

Instructional Materials: Chart

Behavioural Objectives: By the end of the lesson, Students should be able to;

1. Explain the meaning of cytoplast.

2. list the cell organelles and functions.

Entry Behavior: The Students have been taught cell

Instructional Procedure: The teacher presents the topic with the following steps:

Step 1: The teacher presents the concept of cytoplast and its properties as the part of the cell that have different function that sustains the whole cell as the basic structural unit. The teacher mentions different examples of cell to include plant cell, animal cell and notes them on the board.

Step 2: Teacher goes further to mention the cell organelles by listing them on the board and stating at least one function of each of the cell organelles;

i. Nucleus**:** (i)control life activities of the cell (ii) Stores hereditary informationas it contains DNA
ii. Chromosomes: it contains DNA which stores genetic traits
iii. Mitochondria: it is the describe as the power house of the cell. They are sites of respiration or where energy is released from

iv. Vacuole**:** it contain cell saps that act as osmoregulator by helping to remove excess water in the cells

v. Nucleous**:** Produce ribosome for protein synthesis.

vi. Endoplasmic reticulum: it aids transport of materials within the cells

vii. Golgi bodies**:** function in synthesis, packaging and distribution of materials

viii. Chloroplast: contains chlorophyll that aid photosynthesis in green plant

ix. Lysosomes**:** they are sites for respiratory enzymes

x. Ribosomes**:** responsible for protein synthesis

xi. Cell wall: provides protection and shape for the cell

xii. Cell membrane**:** it serves a great role in selective absorption of materials

Evaluation:. The teacher evaluates the Students using the following questions

1. List at least two cell organelles

2. State at least three function of the cell organelles

Conclusion: The teacher summaries the lesson by explaining and making corrections where necessary for the Students.

Assignment: what is cell division and differentiates between mitosis and meiosis.

Topic: cell

Sub-topic: Mitosis

Level: 100

Lesson note: week 3

Period: 1

Date: 15 August, 2024

Instructional Materials: Chart

Behavioural Objectives: By the end of the lesson, Students should be able to;

1. Mention types of cell division

2. Define Mitosis

3. List stages involve in mitosis cell division

Entry Behavior: The Students have been taught cell

Instructional Procedure: The teacher presents the topic with the following steps:

Step 1: The teacher state the types of cell division as mitosis and meiosis

Step 2: The teacher define mitosis as the process by which a cell nucleus divides to produce two daughter nuclei containing identical sets of chromosomes to the parent cells.

Step 3: The teacher list stages involve in mitosis cell division as interphase, prophase, metaphase, anaphase and telophase.

Evaluation:. The teacher evaluates the students using the following questions

1. Mention types of cell division

2. Define Mitosis

3. List stages involve in mitosis cell division

Conclusion: The teacher summaries the lesson by explaining and making corrections where necessary for the Students.

Assignment: explain the procedures involve in meosis cell division.

Appendix III

Lesson Plan on Cell Biology using Conventional Strategy.

Topic: cell and cell theory

Level: 100

Lesson note: week 1

Period: 1

Date: 19 August, 2024

Instructional Materials: Lecture Note

Behavioural Objectives: By the end of the lesson, Students should be able to;

1. Define Cell.

2. Highlight the historical background of Cell concept

3. State the two types of Cell

Entry Behavior: Students are familiar with cell

Instructional Procedure

Step 1: The teacher presents the concept of cell as the basic, structural, functional and biological unit of all known living organism. Cell takes into consideration the chemical processes of life in relation to cell development from prokaryote to eukaryote cell. It is also the study of genetic component of cell with emphasis on DNA and RNA.

Step 2: The teacher goes further to highlight the historical background of Cell concept as: Cell were first described in 1665 by Robert Hooke, a scientist of great talent and versatility who was an accomplished technician and biologist. He designed one of the earliest optical microscopes with which he examined a thin section of cork and discovered that the cork contain a numerous box-like structures which we known to be cells.

Matthias Schleiden and Theodor Schwann a zoologist in the year 1838-1839 produced a cell theory which unified the ideas of the time by stating that the basic unit of structure and function in living organisms is the cell. Then the cell would seem to be a basic structural and functional unit of life of an organism.

Step 3: The teacher State the two types of Cell as Prokaryotic and eukaryotic cell

Prokaryotic cell are the first form of life on earth. They are simpler and smaller than eukaryotic cell and lack membrane bound organelles. Prokaryotic cell include two domain of the domain of life such as bacterial and archers while Eukaryotic cell are fifteen times wider than a typical prokaryote and can be as much as a thousand times greater in volume.

Evaluation: The teacher evaluates the Students using the following questions

1. Define Cell.

2. Highlight the historical background of Cell concept

3. State the two types of Cell

Conclusion/ summary: The teacher summaries the lesson by explaining and making corrections where necessary for the Students

Assignment: Draw a well label diagram of the plant and Animal cell

State at least ten (10) differences between plant and animal cells

Topic: cell

Sub-topic: Cytoplast and its Constituents

Level: 100

Lesson note: week 2

Period: 1

Date: 26 August, 2024

Duration:

Instructional Materials: Lecture Note

Behavioural Objectives: By the end of the lesson, Students should be able to;

1. Explain the meaning of cytoplast.

2. list the cell organelles and functions.

Entry Behavior: The Students have been taught cell

Instructional Procedure: The teacher presents the topic with the following steps:

Step 1: The teacher presents the concept of cytoplast and its properties as the part of the cell that have different function that sustains the whole cell as the basic structural unit. The teacher mentions different examples of cell to include plant cell, animal cell and notes them on the board.

Step 2: Teacher goes further to mention the cell organelles by listing them on the board and stating at least one function of each of the cell organelles;

i. Nucleus**:** (i)control life activities of the cell (ii) Stores hereditary informationas it contains DNA

ii. Chromosomes: it contains DNA which stores genetic traits

iii. Mitochondria: it is the describe as the power house of the cell. They are sites of respiration or where energy is released from

iv. Vacuole**:** it contain cell saps that act as osmoregulator by helping to remove excess water in the cells

v. Nucleous**:** Produce ribosome for protein synthesis.

vi. Endoplasmic reticulum: it aids transport of materials within the cells

vii. Golgi bodies**:** function in synthesis, packaging and distribution of materials

viii. Chloroplast: contains chlorophyll that aid photosynthesis in green plant

ix. Lysosomes**:** they are sites for respiratory enzymes

x. Ribosomes**:** responsible for protein synthesis

xi. Cell wall: provides protection and shape for the cell

xii. Cell membrane**:** it serves a great role in selective absorption of materials

Evaluation:. The teacher evaluates the Students using the following questions

1. List at least two cell organelles

2. State at least three function of the cell organelles

Conclusion: The teacher summaries the lesson by explaining and making corrections where necessary for the Students.

Assignment: what is cell division and differentiates between mitosis and meiosis.

Topic: cell

Sub-topic: Mitosis

Level: 100

Lesson note: week 3

Period: 1

Date: 26 August, 2024

Instructional Materials: Lecture Note

Behavioural Objectives: By the end of the lesson, Students should be able to;

1. Mention types of cell division

2. Define Mitosis

3. List stages involve in mitosis cell division

Entry Behavior: The Students have been taught cell

Instructional Procedure: The teacher presents the topic with the following steps:

Step 1: The teacher state the types of cell division as mitosis and meiosis

Step 2: The teacher define mitosis as the process by which a cell nucleus divides to produce two daughter nuclei containing identical sets of chromosomes to the parent cells.

Step 3: The teacher list stages involve in mitosis cell division as interphase, prophase, metaphase, anaphase and telophase.

Evaluation:. The teacher evaluates the students using the following questions

1. Mention types of cell division

2. Define Mitosis

3. List stages involve in mitosis cell division

Conclusion: The teacher summaries the lesson by explaining and making corrections where necessary for the Students.

Assignment: explain the procedures involve in meosis cell division

Appendix IV

Lead City University, Ibadan,

Department Of Science Education

Biology Achievement Test (BAT)

Multiple Choice Objectives Questions

Section A

Demographic Data

Gender: Male [ ] Female [ ]

Level: NCE 1 [ ]

Name of Institution: …………………

Section B

Instructions: Tick the correct answer for each questions from option A-E

1. Cell is the study of……………………….
   a. Basic structural functional and biological unit of living organisms
   b. Smallest unit of living organism
   c. Chemical processes
   d. Living organisms
   e. Biological unit of living organism
2. In what year cell was first discovered
   a. 1965
   b. 1966
   c. 1765
   d. 1665
   e. 1668
3. How many types of cell do we have
   a. 1
   b. 4
   c. 2
   d. 7
   e. 3
4. Cell comprises of----------------- component

a. RNA and DNA
b. Prokaryotic cell and Eukaryotic cell
c. Plant and animal cell
d. Cytoplast and nucleus
e. Plasmids and cytoplasm

5. ----------------- is the continuous living membrane with the nucleus
a. Cell wall
b. Nucleus
c. Endoplasmic reticulum
d. Ribosome
e. Lysosomes

6. Prokaryotic include two domain of life such as
a. Bacterial and archers
b. Chromatin and granules
c. Nucleus and vacuole
d. Cytoplast and archers
e. Bacterial and nucleus

7. The nucleus gives the name eukaryotes its name meaning
a. False nucleus
b. True nucleus
c. Metabolic nucleus
d. Cytoplasm
e. Golgi apparatus

8. --------------- contains chlorophyll and carries out photosynthesis
a. Chloroplast
b. Water
c. Micro bodies
d. Middle lamella
e. Large vacuole

9. ------------------ is made up of roughly equal parts of protein and RNA
a. Nucleus

b. Mitochondria
c. Lysosomes
d. Ribosome
e. Golgi apparatus

10. ------------------ contains matrix with a few ribosome, a circular DNA molecules and phosphate granules
    a. Mitochondria
    b. Rough endoplasmic reticulum
    c. RNA
    d. Smooth endoplasmic reticulum
    e. Ribosome
11. Cell is bounded by a----------
    a. Animal cell
    b. Plant cell
    c. Thick wall
    d. Soft wall
    e. Tough wall
12. ------------- and ------------- play a major part in maintaining shape form of the cell
    a. Cell sap and cellulose
    b. Cellulose wall and cytoplasm
    c. Cell sap and carbohydrate
    d. Pigment and chlorophyll
    e. Cytoplasm and cell sap
13. Eukaryotic cell are about --------------- times wider than a typical prokaryote
    a. Ten
    b. Five
    c. Fifteen
    d. Eight
    e. Fifty
14. ---------- discovered that cork is composed of numerous box-like structures known as cells

a. John Dalton
b. William wheel
c. Charles Darwin
d. Robert Hooke
e. Shchledien and Schwann

15. If cell is to divide---------will replicate first
a. Genetic material
b. RNA
c. DNA
d. A and c
e. B and c

16. -------------- is the longest phase of division, chromosomes become visible as the contract, nucleus shrink and become shorter and fatter
a. Prophase
b. Anaphase
c. Interphase
d. Metaphase
e. All of the above

17. When a chromosome arrange themselves on equator of spindles is called------------
a. DNA
b. RNA
c. Metaphase
d. Anaphase
e. Non of the above

18. -------------- is the process b which a cell divides to produce a daughter nuclei each containing half the number of chromosomes of the original nucleus
a. Haploid
b. Mitosis
c. Diploid
d. Anaphase
e. Meiosis

19. The daughter cells receive only one of each chromosomes from the ------------

a. Animal cell
b. Daughter cell
c. Parent cell
d. Gamete cell
e. Haploid cell

20. In animal meiosis occurs in the formation of gamete such as-------------

a. Eggs and sperm
b. Gamete and parent cell
c. Parent cell and daughter cell
d. Egg and daughter cell
e. Non of the above

21. Meiosis consists of two successive divisions, the parents cell splits into ------ and -------

a. Daughter cell and parent cells
b. First meiotic division and second meiotic division
c. Fist meiotic division and daughter cell
d. second meiotic division and daughter cell
e. all of the above

22. the significant of mitosis include all expect

a. Genetic stability
b. Growth
c. Regeneration
d. Parent cell
e. Cellular replacement

23. ------------ and ------------meiosis does in two ways

a. Independent assortment of chromosomes and crossing over
b. chromosomes and crossing over
c. Independent assortment and dependent assortment
d. Chromosomes and dependent assortment
e. crossing over and dependent assortment

24. All these are stages of meiosis expect

a. Anaphase
b. Metaphase
c. Telophase
d. Tapelophase
e. Prophase

25. ------------- is responsible for the transmission of the hereditary information from generation to generation
a. Chromosomes
b. Gene
c. Hereditary
d. DNA
e. Molecules

26. -------------- is the number of chromosomes present in dogs
a. 15
b. 25
c. 78
d. 46
e. 100

27. -------------- is surrounded by an envelope of two membranes stroma and grana
a. Plasmodema
b. Middle lamella
c. Micro bodies
d. Chloroplast
e. Nucleus

28. -------------- is the first form of life on earth
a. DNA
b. RNA
c. Prokaryotic
d. Eukaryotic
e. Metabolic activities

29. -------------- and -------------- play a major part in maintaining shape form of the cell

a. Cell sap and cellulose
b. Cellulose wall and cytoplasm
c. Cell sap and carbohydrate
d. Pigment and chlorophyll
e. Cytopalsm and cell sap

30. Eukaryetic cell are about -------------- times wider than a typical prokaryote
    a. Ten
    b. Five
    c. Fifteen
    d. Eight
    e. Fifty

Bio-data

A. Personal Data

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B. Educational Background with Dates

- Lead City University, Ibadan Oyo State - 2022 – till Date
- Lead City University, Ibadan Oyo State - 2019 – 2021
- University of Abuja - 2010 – 2015
- FCT College of Education Zuba - 2006 – 2009
- Government Sec. Sch., Army Barrack Keffi - 1999 – 2005
- Oluwalose Nursery & Primary School, Ekiti - 1994 – 1999

C. Working Experience with Dates

- Federal Government College Sagamu Ogun State. 2015 – 2016
- National Biotechnology Development Agency 2017
- Federal College of Education (Special), Oyo 2017- till Date

D. Award and Fellowships (if any): Nil

E. Membership of Academic/Professional Bodies:

- Member, Teachers' registration council of Nigerian (TRCN)
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F. Publication:

- Agada, A. (2018): Anti biodiversity conservation: A threat to sustainable development. *Journal of Physical Education and Research (JOPER) 22, 2438-24394.*

- Agada, A**.** Onoja, D.M and Umar, M (2019). Science in early childhood education in Nigeria. *International Journal of Primary Education studies (IJPES)* 2(1), 98-108.

- Agada, A. Onoja, D.M and Abioye, J.A.I (2018). Assessment of science learning environment pre-school education. *International Journal of Special and General Education*, 13, 196-207.

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- Agada, A and Dr. Sam-Kayode C.O (2022): Scientific and Technology Innovation for Sustainable Development, A Book of Readings in honour of Prof. Donald Abidemi Odeleye. *Faculty of Arts and Education, Lead City University,* Ibadan. College Press p 245-250.

G. Major Conferences Attended with Dates

- Agada, A. (2017).Economic recovery through science education: *A paper presented at 7thNational conference of school of secondary education (Science Programmes). Federal College of education (Special), Oyo Ibadan.*

- Agada, A. (2020). Roadmap to inclusive education for Special need people through accessible science, Technology and Mathematics Education: *A paper presented at 7th National Conference of school of secondary education (science Programmes), Federal College of Education (Special), Oyo. 17th -19th March.*

- Agada, A. (2022). Parenting styles and its effects on academic achievement of Biology students: *Being a Paper presented at the 6th national association of women in colleges of education (WICE)south west conference and workshop at federal college of education special Oyo. 7th -11thMarch.*
- Agada, A. (2022).Assessing The Role of Biology Education in Improving National Economic and Security. A *paper presented at the 9thbiennial national conference of school of secondary education (science programmes), federal college of education (special), oyo. 6th -9th, june.*

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The University Compliance Certification

This is to certify that the thesis by Allwell Agada ADELEYE with the matric number LCU/PG/000546 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.

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Signature Date