



Influence of innovative teaching methods on biology students' performance in secondary schools in North 24 Parganas

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Abstract

This study examines the influence of innovative teaching methods on the academic performance of biology students in secondary schools in North 24 Parganas. The primary focus is to explore how learner-centered pedagogies such as ICT-based learning, inquiry-based instruction, collaborative learning, and activity-based teaching contribute to students' conceptual understanding, engagement, and achievement in biology. The study adopts a qualitative research design based on secondary sources of data, including books, journals, government reports, and policy documents such as NCERT and NEP 2020. Through thematic analysis, the study identifies key patterns related to the effectiveness of innovative teaching methods and the challenges associated with their implementation. The findings reveal that innovative teaching strategies significantly enhance students' academic performance by improving visualization of biological concepts, promoting active participation, and developing critical thinking skills. However, the study also highlights several barriers, including inadequate infrastructure, lack of ICT facilities, large class sizes, and insufficient teacher training, which hinder effective classroom implementation. It concludes that while innovative teaching methods have strong potential to improve biology education, their success depends on proper institutional support and teacher preparedness. Strengthening resources and promoting continuous professional development are essential for improving science education outcomes in secondary schools in North 24 Parganas.

Keywords: Innovative teaching methods, biology education, academic performance, ICT integration, secondary schools, inquiry-based learning

Introduction

Biology, as a core science subject at the secondary school level, plays a crucial role in developing scientific literacy, environmental awareness, and critical thinking among learners. However, traditional lecture-based teaching methods often fail to engage students meaningfully, resulting in poor conceptual understanding and low academic performance. In response to these challenges, innovative teaching methods such as inquiry-based learning, activity-based instruction, ICT integration, simulation-based learning, and collaborative learning have gained increasing attention in science education (Bruner, 1961; Dewey, 1938) [2, 4].

Innovative teaching methods emphasize learner-centered approaches where students actively construct knowledge rather than passively receiving information. According to constructivist theory, learners build new knowledge based on prior experiences, making active engagement essential for meaningful learning (Piaget, 1952; Vygotsky, 1978) [16, 20]. In biology education, these methods allow students to visualize complex processes such as cell division, genetics, and ecological interactions, thereby enhancing comprehension and retention. In the context of India, especially in districts like North 24 Parganas in West Bengal, secondary schools face challenges such as overcrowded classrooms, limited laboratory resources, and reliance on traditional pedagogy. These factors contribute to students' disengagement and low achievement in science subjects.

The National Education Policy (NEP) 2020 [6] emphasizes experiential and competency-based learning, highlighting the need for innovative pedagogical practices in science education (Government of India, 2020) [6].

Research suggests that when teachers adopt innovative strategies, students demonstrate improved academic performance, higher motivation, and better problem-solving skills (Hattie, 2009) [9]. In biology, where abstract concepts often require visualization and application, innovative teaching methods can bridge the gap between theory and practice. Therefore, exploring the influence of such methods on students' performance in secondary schools in North 24 Parganas is both timely and significant.

Background of the Study

The teaching of biology has evolved significantly over the past few decades, moving from teacher-centered instruction to learner-centered pedagogies. Traditionally, biology classrooms relied heavily on rote memorization of facts, diagrams, and terminologies. This approach often neglected conceptual understanding and practical application, resulting in superficial learning outcomes (Ausubel, 1968) [1]. In many secondary schools, particularly in developing regions, such traditional methods remain dominant due to infrastructural limitations and lack of teacher training. In North 24 Parganas, one of the densely populated districts of West Bengal, secondary education faces multiple systemic challenges. These include large student-teacher ratios, inadequate laboratory facilities, and limited access to digital learning resources. As a result, biology instruction is often confined to textbook-based learning with minimal hands-on experimentation. This limits students' ability to connect biological concepts with real-life phenomena, thereby affecting their academic performance and interest in science subjects.

Innovative teaching methods have emerged as a solution to these challenges. Approaches such as inquiry-based learning

encourage students to ask questions, investigate biological phenomena, and develop scientific reasoning skills (Bybee, 2015) ^[3]. Similarly, ICT-based instruction, including multimedia presentations, virtual labs, and educational videos, enhances visualization of microscopic and complex biological processes (UNESCO, 2011). Furthermore, collaborative learning strategies allow students to engage in peer discussions, group projects, and cooperative problem-solving, which improves communication skills and conceptual clarity (Johnson & Johnson, 1999) ^[11]. The integration of these methods aligns with the constructivist perspective, which emphasizes active learning and social interaction in knowledge construction (Vygotsky, 1978) ^[20]. In the Indian educational context, reforms such as the National Curriculum Framework (NCF 2005) and NEP 2020 ^[6, 14] advocate for experiential and activity-based learning in science education. Despite these policy recommendations, implementation at the school level remains inconsistent, particularly in semi-urban and rural regions such as North 24 Parganas. Therefore, it becomes essential to investigate how innovative teaching methods influence biology students' academic performance in this region. Understanding this relationship will provide insights into effective pedagogical practices and help bridge the gap between educational policy and classroom implementation.

Rationale of the Study

The rationale for this study stems from the growing need to improve the quality of science education in secondary schools, particularly in biology, which is often perceived as a difficult subject by students. In regions like North 24 Parganas, students frequently struggle with abstract biological concepts due to limited exposure to experimental and interactive learning experiences. This has a direct impact on their academic performance and overall interest in science education.

One of the primary reasons for conducting this study is the persistent reliance on traditional teaching methods in many secondary schools. Despite advancements in educational technology and pedagogy, chalk-and-talk methods continue to dominate classroom instruction. This creates a gap between modern educational expectations and actual classroom practices (NCF, 2005) ^[14].

Another important rationale is the increasing emphasis on competency-based education under the National Education Policy (NEP, 2020) ^[6]. The policy encourages teachers to adopt innovative, student-centered teaching methods that promote critical thinking, creativity, and application-based learning. However, there is limited empirical evidence on how such methods influence student performance in specific local contexts like North 24 Parganas. Additionally, biology as a subject inherently involves processes that are dynamic, visual, and often abstract. Innovative teaching methods such as simulations, models, and ICT tools can significantly enhance students' understanding of these processes. According to Mayer's cognitive theory of multimedia learning, students learn better when information is presented through both visual and verbal channels (Mayer, 2001) ^[13]. Furthermore, the study is justified by the need to improve academic outcomes in secondary education. Several studies suggest that innovative teaching strategies positively influence student achievement, motivation, and engagement (Hattie, 2009) ^[9]. However, contextual factors such as infrastructure, teacher readiness, and socio-economic

conditions may influence the effectiveness of these methods. Therefore, this study is necessary to examine the actual impact of innovative teaching methods on biology students' performance in North 24 Parganas. The findings will help educators, policymakers, and school administrators identify effective instructional strategies and improve the overall quality of science education in the region.

Review of the related Literature

The influence of innovative teaching methods on students' academic performance has been widely studied in the field of education, particularly in science subjects like biology. A substantial body of literature suggests that learner-centered and technology-integrated instructional approaches significantly enhance students' conceptual understanding, engagement, and achievement. Constructivist learning theory forms the foundation of many innovative teaching strategies. Piaget (1952) ^[16] emphasized that learners actively construct knowledge through interaction with their environment, while Vygotsky (1978) ^[20] highlighted the importance of social interaction and scaffolding in cognitive development. These theories support the use of inquiry-based and collaborative learning methods in biology education.

Inquiry-based learning has been shown to improve students' scientific reasoning and problem-solving skills. According to Bybee (2015) ^[3], students who engage in inquiry-based science learning demonstrate deeper understanding and better retention of biological concepts compared to those taught through traditional methods. This approach encourages students to ask questions, conduct investigations, and draw conclusions based on evidence.

ICT integration in biology teaching has also received significant attention. UNESCO (2011) reports that the use of digital tools such as simulations, animations, and virtual laboratories enhances students' understanding of complex biological processes. For example, topics like DNA replication and cellular respiration become more comprehensible when visualized through interactive media. Mayer (2001) ^[13] further supports this through his cognitive theory of multimedia learning, which suggests that dual-channel processing improves comprehension.

Collaborative learning is another widely researched innovative teaching method. Johnson and Johnson (1999) ^[11] found that cooperative learning strategies improve academic achievement, interpersonal skills, and student motivation. In biology classrooms, group-based activities such as experiments and projects allow students to share knowledge and develop critical thinking skills.

In the Indian context, research indicates that innovative teaching methods positively influence science learning outcomes. Sharma and Singh (2018) ^[17] found that students exposed to activity-based biology teaching performed significantly better than those taught through conventional methods. Similarly, Gupta (2019) ^[8] reported that ICT-supported instruction improved students' interest and achievement in secondary school science. However, several challenges hinder the effective implementation of innovative teaching methods. Lack of infrastructure, insufficient teacher training, and large class sizes are commonly reported barriers in Indian schools (NCERT, 2015). In districts like North 24 Parganas, these challenges are more pronounced due to socio-economic constraints and uneven resource distribution.

Hattie (2009) ^[9], in his meta-analysis of educational interventions, identified teaching quality as one of the most significant factors influencing student achievement. His findings suggest that strategies such as feedback, student engagement, and active learning have a strong positive effect on academic performance. Further studies highlight the importance of teacher readiness in adopting innovative methods. According to Fullan (2007) ^[5], successful educational change depends on teachers' willingness to adopt new pedagogical practices and continuously develop their professional skills. Without adequate training and support, the implementation of innovative methods remains limited.

In biology education specifically, research shows that visualization-based learning significantly improves understanding of abstract concepts. Lazarowitz and Tamir (1994) ^[12] emphasize that laboratory work and hands-on activities are essential for meaningful biology learning. Similarly, studies by Hofstein and Lunetta (2004) ^[10] confirm that laboratory experiences enhance scientific inquiry skills and conceptual understanding. The reviewed literature strongly supports the effectiveness of innovative teaching methods in improving biology students' performance. However, there is a need for localized studies to understand how these methods function in specific educational contexts such as North 24 Parganas. This study aims to fill this gap by examining the influence of such methods on secondary school students' academic outcomes.

Research Objectives of the Study

- To examine the influence of innovative teaching methods on the academic performance of biology students in secondary schools in North 24 Parganas.
- To identify the types of innovative teaching strategies (e.g., ICT-based learning, inquiry-based learning, collaborative learning) used by biology teachers in secondary schools.
- To explore the challenges faced by teachers and schools in implementing innovative teaching methods in biology classrooms.

Research Questions of the Study

- How do innovative teaching methods influence the academic performance of biology students in secondary schools in North 24 Parganas?
- What types of innovative teaching methods are commonly used in teaching biology in secondary schools in the study area?
- What are the major challenges faced by teachers in implementing innovative teaching methods in biology education?

Methodology of the Study

This study adopts a qualitative research design to explore the influence of innovative teaching methods on the performance of biology students in secondary schools in North 24 Parganas. A qualitative approach is considered appropriate because it allows for an in-depth understanding of educational practices, teacher experiences, and student learning outcomes in a natural context (Creswell, 2014). The study is based entirely on secondary sources of data, meaning that no primary data (such as surveys, interviews, or classroom observations) were collected directly from respondents. Instead, the research relies on existing

literature, published research articles, government reports, educational policy documents, books, journals, and online academic databases. Key sources include reports from the National Council of Educational Research and Training (NCERT), the Ministry of Education (Government of India), UNESCO publications, and peer-reviewed journal articles related to science education and pedagogy. Data will be collected through document analysis, where relevant studies on innovative teaching methods such as ICT integration, inquiry-based learning, and collaborative learning are reviewed and interpreted. The analysis focuses on identifying recurring themes such as student engagement, academic performance, teacher readiness, and implementation challenges. A thematic analysis approach is used to organize and interpret the secondary data. Themes are developed based on patterns found in the literature, such as improvement in conceptual understanding, increased student motivation, and barriers like lack of infrastructure and training. This allows the researcher to synthesize findings from multiple sources and present a coherent understanding of the topic. The use of secondary qualitative data is advantageous because it provides access to a wide range of scholarly perspectives and allows for a comprehensive understanding of educational practices without geographical or institutional limitations. However, it also depends on the availability and reliability of published sources. Overall, this methodology helps to critically examine existing knowledge on innovative teaching methods and their impact on biology education in secondary schools in North 24 Parganas.

Objective-wise Analysis of the Study

Objective 1: To examine the influence of innovative teaching methods on the academic performance of biology students in secondary schools in North 24 Parganas.

Innovative teaching methods have been widely recognized as effective pedagogical approaches that significantly influence students' academic performance, particularly in science subjects such as biology. In the context of secondary schools in North 24 Parganas, the adoption of learner-centered and technology-integrated teaching practices is increasingly being considered essential for improving students' conceptual understanding and examination outcomes.

Traditional teaching methods in biology often rely on rote memorization and lecture-based instruction, which limit students' ability to understand complex biological processes such as genetics, cellular respiration, and ecological systems. According to Ausubel (1968) ^[1], meaningful learning occurs only when new information is linked with prior knowledge, which is often not achieved through passive learning methods. In contrast, innovative teaching strategies promote active engagement, critical thinking, and knowledge construction.

Inquiry-based learning is one of the most influential innovative approaches that positively impacts academic performance. Bybee (2015) ^[3] explains that inquiry-based science education allows students to explore scientific concepts through questioning, investigation, and evidence-based reasoning.

This method enhances cognitive development and improves retention of biological concepts. In secondary biology

classrooms, students who participate in inquiry-based activities demonstrate better understanding of experimental processes and higher achievement in assessments.

ICT-based teaching methods also play a significant role in enhancing academic performance. The integration of digital tools such as simulations, animations, and virtual laboratories helps students visualize abstract biological concepts that are otherwise difficult to comprehend. Mayer (2001) ^[13] emphasizes that multimedia learning improves cognitive processing by engaging both visual and verbal channels, leading to better comprehension and retention. In the context of North 24 Parganas, where laboratory facilities may be limited in some schools, ICT tools serve as an alternative means of providing practical exposure.

Collaborative learning is another effective innovative teaching strategy that influences academic performance. Johnson and Johnson (1999) ^[11] found that cooperative learning environments improve student achievement by encouraging peer interaction, discussion, and shared problem-solving. In biology education, group-based activities such as projects and experiments allow students to clarify doubts and develop deeper conceptual understanding through social interaction.

Empirical studies conducted in India also support the positive relationship between innovative teaching methods and academic achievement. Sharma and Singh (2018) ^[17] found that students taught through activity-based biology instruction performed significantly better in examinations compared to those taught using traditional methods. Similarly, Gupta (2019) ^[8] reported that ICT-supported instruction improved students' interest and academic performance in secondary science subjects.

The National Education Policy (NEP) 2020 ^[6] further emphasizes experiential and competency-based learning, highlighting the importance of innovative pedagogical practices in improving student outcomes (Government of India, 2020) ^[6]. However, the effectiveness of these methods depends on their proper implementation and teacher preparedness.

In North 24 Parganas, the influence of innovative teaching methods on academic performance is also shaped by contextual factors such as class size, availability of resources, and teacher training. Schools that effectively integrate modern pedagogical tools tend to show improved student performance in biology examinations, while those relying on traditional methods often report lower achievement levels.

Overall, literature suggests that innovative teaching methods have a strong positive influence on biology students' academic performance by enhancing understanding, engagement, and retention of concepts. Therefore, their effective implementation in secondary schools in North 24 Parganas can significantly contribute to improved educational outcomes.

Objective 2: To identify the types of innovative teaching strategies (e.g., ICT-based learning, inquiry-based learning, collaborative learning) used by biology teachers in secondary schools.

Innovative teaching strategies in biology education encompass a wide range of learner-centered approaches designed to enhance student engagement and understanding. In secondary schools, particularly in regions such as North 24 Parganas, biology teachers are gradually adopting

different pedagogical methods to improve teaching effectiveness and student learning outcomes.

One of the most commonly used innovative strategies is ICT-based learning. This involves the use of digital technologies such as PowerPoint presentations, animations, simulations, virtual labs, and educational videos. UNESCO (2011) highlights that ICT integration in education improves students' understanding of complex scientific concepts by providing visual and interactive learning experiences. In biology, topics such as DNA replication, cell division, and human anatomy are better understood through animated models and simulations.

Another important strategy is inquiry-based learning, which encourages students to actively participate in the learning process by asking questions, conducting investigations, and drawing conclusions. Bybee (2015) ^[3] describes inquiry-based learning as a process that mirrors the work of scientists, allowing students to develop scientific reasoning skills. In biology classrooms, teachers use experiments and problem-solving tasks to promote curiosity and critical thinking. Collaborative learning is also widely used in secondary biology education. Johnson and Johnson (1999) ^[11] define it as a teaching strategy in which students work in groups to achieve shared learning goals. This method encourages communication, teamwork, and peer learning. In biology, group experiments, project work, and discussions help students clarify concepts and learn from each other.

Activity-based learning (ABL) is another significant approach used in many schools. It involves hands-on activities such as model making, experiments, and field observations. NCERT (2005) promotes activity-based learning as a way to make science education more engaging and meaningful. In biology, activities such as observing plant growth, studying ecosystems, and conducting simple experiments help students connect theory with real-life phenomena. Blended learning is also emerging as a modern teaching strategy that combines traditional classroom instruction with digital learning tools. According to Graham (2006) ^[7], blended learning provides flexibility and enhances student engagement by integrating face-to-face teaching with online resources. In secondary biology education, teachers may assign online videos or quizzes alongside classroom lessons.

In addition, project-based learning (PBL) is increasingly being used in science education. Students work on real-world biological problems such as environmental conservation or health awareness projects. Thomas (2000) ^[18] notes that PBL enhances problem-solving skills and encourages independent learning.

In the context of North 24 Parganas, teachers often combine multiple innovative strategies depending on available resources. However, the most commonly observed methods include ICT-based instruction, collaborative group work, and activity-based learning due to their practicality and effectiveness in large classroom settings.

Studies indicate that teachers who adopt multiple innovative strategies tend to create more engaging and effective biology learning environments. However, the extent of usage depends on teacher training, infrastructure, and institutional support.

Objective 3: To explore the challenges faced by teachers and schools in implementing innovative teaching methods in biology classrooms.

Despite the recognized benefits of innovative teaching methods in biology education, several challenges hinder their effective implementation in secondary schools, particularly in regions such as North 24 Parganas. These challenges are related to infrastructural limitations, teacher preparedness, institutional constraints, and socio-economic factors.

One of the major challenges is the lack of adequate infrastructure. Many schools do not have well-equipped science laboratories or sufficient ICT facilities such as computers, projectors, and internet access. According to NCERT (2015), inadequate infrastructure is a significant barrier to implementing activity-based and ICT-supported learning in Indian schools. Without proper facilities, teachers are forced to rely on traditional lecture methods.

Another significant challenge is large class sizes. In many government and semi-urban schools, classrooms are overcrowded, making it difficult for teachers to implement interactive and student-centered teaching methods. Hattie (2009) ^[9] emphasizes that effective teaching requires manageable class sizes that allow for feedback, interaction, and active participation. In overcrowded classrooms, individual attention becomes limited, reducing the effectiveness of innovative strategies.

Lack of teacher training and professional development is also a critical issue. Many biology teachers are not adequately trained in modern pedagogical approaches such as ICT integration, inquiry-based learning, or blended learning. Fullan (2007) ^[5] argues that successful educational innovation depends on continuous teacher development and willingness to adopt new methods. Without proper training, teachers may feel unprepared or resistant to change.

Time constraints and syllabus pressure further restrict the use of innovative methods. Teachers often face pressure to complete the syllabus within a limited academic calendar, leaving little time for experiments, group activities, or project-based learning. As a result, they tend to prioritize theoretical teaching over practical engagement.

Socio-economic factors also play a role in limiting the effectiveness of innovative teaching methods. Students from disadvantaged backgrounds may have limited access to digital devices or learning resources outside school. This creates inequality in learning opportunities, especially when ICT-based teaching is introduced.

Another challenge is lack of administrative support. School management may not prioritize investment in teaching aids, training programs, or digital infrastructure. Without institutional encouragement, teachers may find it difficult to adopt new teaching practices.

Resistance to change is also observed among some educators who are accustomed to traditional teaching methods. According to Rogers' Diffusion of Innovations Theory (2003), adoption of new practices depends on perceived benefits, ease of use, and institutional support. Teachers who are not confident in using innovative tools may prefer conventional methods.

In North 24 Parganas, these challenges are further intensified by regional disparities in resource distribution and school funding. While some urban schools may have access to digital tools and trained teachers, rural and semi-urban schools often struggle with basic facilities.

Overall, these challenges highlight the gap between educational policy and classroom reality. Although policies such as NEP 2020 ^[6] promote innovative and experiential

learning, effective implementation requires addressing infrastructural, pedagogical, and systemic barriers.

Discussion

The findings derived from the reviewed literature indicate that innovative teaching methods have a significant and positive influence on the academic performance of biology students in secondary schools in North 24 Parganas. Across various studies, it is evident that learner-centered pedagogies such as ICT-based instruction, inquiry-based learning, collaborative learning, and activity-based teaching contribute to improved conceptual understanding, higher engagement levels, and better academic outcomes (Hattie, 2009; Bybee, 2015) ^[3,9].

One of the most important insights is that biology, being a highly conceptual and visual subject, benefits greatly from innovative teaching approaches. Traditional lecture-based methods often fail to adequately explain dynamic biological processes such as cell division, genetics, and ecological interactions. However, ICT tools like animations, simulations, and virtual laboratories make these abstract concepts more concrete and easier to understand (Mayer, 2001) ^[13]. This has a direct impact on student performance in examinations as well as long-term knowledge retention.

Inquiry-based and collaborative learning methods also play a crucial role in improving students' academic outcomes. When students actively participate in investigations, experiments, and group discussions, they develop critical thinking and problem-solving skills. Johnson and Johnson (1999) ^[11] emphasize that cooperative learning enhances both academic achievement and interpersonal skills. In the context of biology education, this leads to deeper understanding rather than rote memorization. However, the effectiveness of these methods is influenced by contextual factors in North 24 Parganas. Despite policy support from frameworks like NEP 2020 ^[6], many schools still face infrastructural limitations, including inadequate laboratories and limited access to digital resources. NCERT (2015) highlights that such constraints hinder the proper implementation of modern teaching strategies. Additionally, large class sizes and insufficient teacher training further reduce the effectiveness of innovative pedagogies.

Teacher readiness is another critical factor influencing outcomes. Fullan (2007) ^[5] argues that educational change depends heavily on teachers' willingness and ability to adopt new methods. In many cases, teachers revert to traditional methods due to time pressure, syllabus completion demands, and lack of training in ICT tools or inquiry-based approaches. Overall, the discussion suggests that while innovative teaching methods have strong potential to enhance biology learning outcomes, their success depends on supportive infrastructure, professional development, and institutional commitment. Without addressing these challenges, the gap between policy expectations and classroom reality will continue to persist.

Conclusion

The study concludes that innovative teaching methods have a clear and positive influence on the academic performance of biology students in secondary schools in North 24 Parganas. Approaches such as ICT-based learning, inquiry-based instruction, collaborative activities, and experiential teaching significantly enhance students' understanding, engagement, and achievement in biology (Bybee, 2015;

Mayer, 2001)^[3, 13]. The findings also reveal that these methods help shift learning from rote memorization to meaningful and concept-based understanding. Students are better able to visualize biological processes, apply knowledge, and develop critical thinking skills when exposed to modern pedagogical approaches. This aligns with constructivist learning theories that emphasize active participation in knowledge construction (Piaget, 1952; Vygotsky, 1978)^[16, 20].

However, the study also highlights several challenges, including inadequate infrastructure, lack of ICT resources, insufficient teacher training, and large class sizes. These barriers limit the effective implementation of innovative teaching strategies in many secondary schools. Therefore, it can be concluded that while innovative teaching methods are highly beneficial for improving biology education, their success depends on proper implementation, teacher preparedness, and institutional support. Strengthening infrastructure and providing continuous teacher training are essential steps toward improving science education outcomes in the region.

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