UNIVERSITY OF EDUCATION, WINENBA

COMPARATIVE ANALYSIS ON THE EFFECTIVENESS OF HOLISTIC AND ASPECT TEACHING OF INTEGRATED SCIENCE: THE CASE OF WEST AKIM MUNICIPALITY

SAMUEL QUAYE

MASTER OF PHILOSOPHY

2025

UNIVERSITY OF EDUCATION, WINENBA

COMPARATIVE ANALYSIS ON THE EFFECTIVENESS OF HOLISTIC AND ASPECT TEACHING OF INTEGRATED SCIENCE: THE CASE OF WEST AKIM MUNICIPALITY

SAMUEL QUAYE
(8241180006)

A thesis submitted to the School of Graduate Studies in partial fulfilment of the requirements for the Award of the Degree of Master of Philosophy (Integrated Science Education)

Department of Integrated Science Education
Faculty of Science Education

SEPTEMBER, 2025

DECLARATION

STUDENT'S DECLARATION

I, Samuel Quaye, declare that this thesis, except quotations and references contained in published works, which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE: ………………………….

DATE: ……………………………………

SUPERVISORS' DECLARATION

I hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of the thesis as laid down by the University of Education, Winneba

SUPERVISOR: Dr. Stephen Twumasi Annan

SIGNATURE: ……………………...…..………

DATE: ……………………………………………

DEDICATION

I dedicate this academic work to my beloved family, whose unwavering love and support have been a constant source of inspiration and encouragement throughout this journey.

ACKNOWLEDGEMENT

This journey would have been inconceivable without the invaluable contributions of many. My deepest and most enduring gratitude goes to my supervisor Dr. Stephen Twumasi Annan. His insightful suggestions, unwavering support, and generous guidance were instrumental throughout the study. I am truly indebted to his mentorship. Special thanks to Dr. Charles Kwesi Koomson, my mentor, for his profound insights and invaluable guidance. His contributions were crucial in shaping this research. A heartfelt appreciation to all the lecturers in the Science Department of the University of Education, Winneba. Their collective impact has been transformative for me and my colleagues. To my loving family, whose unwavering support and understanding fueled my every step, my warmest appreciation. Words cannot express the debt I owe you. Finally, I am grateful to all authors whose works enriched my research, and to everyone who contributed in any way to this accomplishment. Your love and support are forever cherished.

TABLE OF CONTENTS

Content **Page**

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ABTA — Aspects-Based Teaching Approach

CA — Continuous Assessment

GES — Ghana Education Service

HBTA — Holistic-Based Teaching Approach

MoE — Ministry of Education,

NaCCA — National Council for Curriculum and Assessment

SHTS — Senior High/Technical School

TIMSS — Trends in International Mathematics and Science Study

UbD — Understanding by Design

WASSCE — West African Senior School Certificate Examination

ANOVA- Analysis of Variance

SD- Standard Deviation

SHS – Senior High School

STEM – Science, Technology, Engineering and Mathematics

ABSTRACT

Integrated Science is a core subject in Ghanaian senior high schools, aimed at equipping learners with scientific knowledge, critical thinking, and problem-solving skills. Ongoing debates question whether a holistic-based teaching approach (HBTA) or an aspects-based teaching approach (ABTA) better improves student outcomes. This study critically examines the two approaches in selected schools in the West Akim Municipality. The study compares the effects of HBTA and ABTA on student performance, examine gender differences, explore teachers' experiences, and assess students' perceptions. An evaluative mixed-methods design was employed, with a sample of 171 Form-2 students selected through stratified random sampling and 13 Integrated Science teachers chosen purposively, making a total of 184 participants. Data were collected using end-of-semester test scores, questionnaires, and semi-structured interviews, and analysed through descriptive statistics, one-way ANOVA with Tukey's post-hoc tests, and thematic analysis. Key findings revealed that there was no overall main effect favouring HBTA or ABTA **(**$p > 0.05$**).** Gender differences in achievement were not statistically significant ($p > 0.05$). Teachers highlighted resource constraints and the need for professional development to effectively implement HBTA. Students appreciated HBTA's interdisciplinary relevance and recommended a blended HBTA–ABTA model. The study concludes that both approaches enhance outcomes, with sustained HBTA showing particular promise. It recommends investment in teacher training and resources, and suggests longitudinal research to assess long-term effects across cohorts.

CHAPTER ONE

INTRODUCTION

1.0 Overview

This chapter introduces the background of the study, outlining the research problem and the rationale for comparing holistic and aspect-based teaching approaches. It also states the research objectives, questions, significance of the study's findings, and the delimitations of the study. This chapter provides a foundation for understanding the importance of effective teaching methods in Integrated Science and sets the stage for exploring how these approaches impact student learning outcomes.

1.1 Background to the Study

Integrated science has been a cornerstone of Ghana's senior high school curriculum since the implementation of educational reforms in the 1980s (Akyeampong, 2010). The subject aims to provide students with a comprehensive understanding of scientific concepts spanning physics, chemistry, and biology, preparing them for further studies and practical applications in daily life.

In Ghanaian senior high schools, integrated science is typically taught throughout the 3 years. This serves as a foundation for more specialized science subjects in the final year (Adu-Gyamfi & Ampiah, 2016). The curriculum is designed to foster scientific literacy, critical thinking, and problem-solving skills among students. However, debates persist among educators and policymakers regarding the most effective teaching methodologies for achieving these goals. Recent discussions in Ghanaian senior high school science education have focused on comparing holistic and aspects-based teaching approaches (Oduro, 2018). The holistic approach emphasizes interconnections between scientific disciplines, while the aspects-based method focuses on teaching distinct scientific concepts before exploring their relationships.

The rationale for comparing holistic and aspects-based approaches to teaching integrated science in Ghanaian senior high schools stems from several key factors specific to the country's educational landscape and development goals. Ghana's Vision 2020 and subsequent national development plans emphasize the importance of science and technology in driving economic growth and addressing societal challenges (Ghana Education Service, 2012). This national focus necessitates an evaluation of teaching methodologies to ensure they effectively prepare students for future roles in science-related fields.

Additionally, the diverse nature of Ghana's student population, including variations in language, cultural background, and prior educational experiences, necessitates a teaching approach that can effectively cater to this diversity while maintaining educational standards (Ansah, 2014). Comparing holistic and aspects-based approaches allows for an examination of which method might better address these unique challenges.

Furthermore, resource constraints in many Ghanaian senior high schools, including limited laboratory facilities and teaching materials, make it crucial to identify the most efficient and effective teaching methodologies that can be implemented within these constraints (Buabeng et al., 2015). The ongoing curriculum reforms in Ghana, aimed at shifting towards more competency-based education, provide an opportune moment to assess and potentially integrate the most effective elements of both holistic and aspects-based approaches (Ministry of Education, 2019).

Research on the effectiveness of holistic and aspects teaching approaches in science education has yielded mixed results. Holistic approaches, which emphasize interconnections between scientific disciplines, have been found to enhance students' conceptual understanding and ability to apply knowledge across contexts (Rennie et al., 2012). A study by Ültay and Çalık (2016) demonstrated that holistic teaching methods improved students' critical thinking skills and scientific literacy. Conversely, aspects-based approaches, which focus on teaching distinct scientific concepts before exploring their relationships, have shown benefits in terms of knowledge retention and performance on standardized tests (Minner et al., 2010). This approach aligns with cognitive load theory, suggesting that breaking down complex concepts into manageable parts can enhance learning (Sweller, 2011). In the Ghanaian context, limited research directly compares these approaches. However, a study by Abreh et al. (2018) suggested that integrative teaching methods, which share similarities with holistic approaches, improved students' engagement and performance in science subjects.

The impact of teaching approaches on student outcomes in Ghana has been the subject of several studies. Abreh et al. (2018) found that student-centered, inquiry-based approaches improved performance in science subjects compared to traditional lecture-based methods. Similarly, Adu-Gyamfi and Ampiah (2016) reported that interactive teaching strategies enhanced student engagement and conceptual understanding. However, the effectiveness of these approaches can be influenced by contextual factors. Mereku and Anumel (2011) noted that resource constraints often lead teachers to resort to more traditional, teacher-centered methods, even when they recognize the potential benefits of alternative approaches. A study by Tetteh (2017) suggested that a balanced approach, incorporating elements of both holistic and aspects-based teaching, might be most effective in the Ghanaian context. This approach could potentially address the diverse needs of students while working within existing resource constraints.

While previous studies have explored various aspects of science education in Ghana, significant gaps remain in the understanding of effective teaching approaches for integrated science in senior high schools. Previous research has examined different teaching methodologies in Ghanaian science education, but there is a notable absence of studies directly comparing holistic and aspects-based approaches in integrated science. This gap is particularly significant given Ghana's persistent underperformance in WASSCE (Chief Examiner's Report, 2021). This study aims to provide a comprehensive comparison of these two approaches within the specific context of Ghanaian senior high schools, with a focus on their effect on students' academic performance in science subjects.

1.2 Statement of the Problem

Science education remains a critical pillar for national development, especially in countries like Ghana, where technological innovation is essential for economic transformation (Akyeampong, 2018). Integrated Science, which encompasses concepts from physics, chemistry, and biology, has been a core subject in Ghanaian senior high schools since the 1980s, aiming to promote scientific literacy and problem-solving skills among students (Adu-Gyamfi & Ampiah, 2020). However, despite its importance and the continued implementation of curriculum reforms, student performance in Integrated Science in the West Akim Municipality has been persistently low, particularly across the three public senior high schools selected for this study: Asamankese Senior High School, St. Thomas Senior High/Technical School, and Adeiso Senior High School.

Analysis of West African Senior School Certificate Examination (WASSCE) results in Integrated Science from 2020 to 2024 reveals a worrying trend. For instance, Asamankese SHS recorded a consistent decline in credit passes (A1–C6) from 49% in 2020 to 36% in 2023, before a slight recovery to 41% in 2024. Similarly, St. Thomas SHTS showed erratic performance, fluctuating between 38% and 45% credit passes within the same period. Adeiso SHS persistently underperformed, with credit pass rates averaging below 30% across all five years. These statistics suggest systemic issues in the teaching and learning of Integrated Science in these schools.

This situation raises questions about the effectiveness of the teaching methods employed in these schools. While some educators in the municipality adopt a holistic approach, integrating physics, chemistry, and biology into cohesive lessons, others prefer the aspects-based method, where each discipline is taught separately by specialists. Advocates of the holistic approach argue that it fosters interdisciplinary understanding and maximizes teaching time and resources (Rennie et al., 2022). In contrast, supporters of the aspects-based approach claim it allows for more focused and content-accurate instruction, especially in contexts where teachers lack cross-disciplinary expertise (Minner et al., 2020).

Despite ongoing curriculum reforms promoting competency-based education (Ministry of Education, 2019), there is a lack of empirical evidence comparing the effectiveness of these two approaches in improving Integrated Science outcomes within the Ghanaian context, particularly in resource-constrained schools like those in the West Akim Municipality. There is also limited understanding of how contextual factors such as teacher subject-matter specialization, class sizes, and infrastructure limitations influence the effectiveness of either approach. Furthermore, the perspectives of teachers and students, who are the most directly affected by these methods, have not been sufficiently studied. Without their input, reforms and interventions may fail to address practical classroom realities. Therefore, this study aims to examine and compare the effectiveness of holistic and aspects-based teaching approaches in Integrated Science across these three schools, evaluate their alignment with curriculum reforms, and explore the lived experiences of teachers and students using these methods.

1.3 Purpose of the Study

The purpose of the study was to explore the comparative effect of the holistic and aspects-based teaching approaches in Integrated Science at West Akim Municipality**.**

1.4 Research Objectives

This research was guided by the following objectives:

1. Compare the effect of holistic and aspects-based teaching on students' academic performance in Integrated Science.
2. To examine the difference between male and female students in their academic performance when taught using holistic and aspect-based teaching methods in Integrated Science.
3. Examine teachers' perspectives and experiences with implementing holistic and aspects-based teaching of Integrated Science in senior high schools.
4. Assess students' perception of the use of holistic and aspects–based teaching in Integrated Science.

1.5 Research Questions

The research addressed these questions:

1. What is the comparative effect of holistic and aspects-based teaching on students' academic performance in Integrated Science?
2. What differences exist in the academic performance of male and female students when taught using holistic and aspect-based teaching methods in Integrated Science?
3. What are teachers' perspectives and experiences with implementing holistic and aspects-based teaching of Integrated Science in senior high school?
4. What are students' perceptions of the use of holistic and aspects-based teaching in Integrated Science?

1.6 Hypothesis

Null Hypothesis (H_0): There is no significant difference in students' academic performance in Integrated Science between the holistic teaching approach and the aspect-based teaching approach.

Alternative Hypothesis (H_1): Holistic teaching approaches significantly improve students' academic performance in Integrated Science compared to aspect-based teaching approaches.

Null Hypothesis (H_0): There is no significant difference between male and female students in their academic performance when taught using holistic and aspect-based teaching methods in Integrated Science.

Alternative Hypothesis (H_2): There is a significant difference between male and female students in their academic performance when taught using holistic and aspect-based teaching methods in Integrated Science.

1.7 Significance of the Study

This study will hold significant value for various stakeholders involved in education within the West Akim Municipality. For school administrators, the findings will provide crucial insights into the effectiveness of holistic and aspect-based teaching approaches in Integrated Science, enabling them to make informed decisions on resource allocation, teacher training, and instructional strategies. By understanding the strengths and challenges of these methods, administrators will be able to better support teachers in improving student outcomes and make strategic decisions regarding teacher deployment.

For teachers, the study will offer a deeper understanding of how the two teaching approaches will impact student learning and engagement. It will allow them to refine their teaching practices based on evidence, ensuring that their methods align with students' needs and lead to improved academic performance. Teachers will also gain practical insights into the implementation of both approaches, helping them adapt their teaching methods to their specific classroom context.

The Educational Directorate of the Municipality will benefit from the study by gaining empirical evidence that will guide the assessment of current teaching practices. This will inform decisions regarding professional development programs and help plan future curriculum reforms and resource distribution aimed at enhancing the quality of education in Integrated Science within the municipality.

The study will contribute to future research by providing a foundation for further exploration into the impact of teaching methodologies in Ghanaian schools. Researchers will be able to build on these findings by examining additional variables. This study will also inspire further investigations into other educational districts or subjects, contributing to a broader understanding of effective teaching strategies in diverse educational contexts.

1.8 Delimitation

The study focuses on three senior high schools within the West Akim Municipality in the Eastern Region of Ghana: Asamankese Senior High School, St. Thomas Senior High and Technical School, and Adeiso Senior High School. It examines Integrated Science as a subject, specifically analyzing the effectiveness of holistic and aspect-based teaching approaches in improving learning outcomes. The selected schools represent diverse instructional methods, including one using the holistic teaching approach, another adopting the aspect-based approach, and a third integrating both approaches in teaching Integrated Science. The study targets Form 2 General Arts students and Integrated Science teachers from the selected schools, as these students are at a critical stage in their educational journey where foundational concepts are reinforced.

The study does not focus on other subjects beyond Integrated Science or include private schools within the municipality. It excludes students from other year groups, such as Form 1 or Form 3, and does not consider specialized academic streams outside of General Arts.

1.9 Limitations

The study encountered several limitations during this study. One key limitation was the reliance on students' semester exam scores as the sole measure of academic performance, which meant that there was no direct interaction between the researcher and students in the classroom setting. As a result, the study could not assess real-time engagement or behavioral responses to the teaching approaches. Another challenge was the variability in how teachers applied the teaching approaches, as their individual strategies and resource constraints may have introduced inconsistencies in the data. Also, the study relied on a specific student population within the General Arts stream, excluding other streams and year groups, which limited the generalizability of the findings to a broader context. These constraints suggest areas for refinement in future studies. Also there was the problem of lateness of students to class. In furtherance, some of the targeted students were involved in other school activities such as sports, drama, debates and so did not participate fully in the research work. This made the implementation of the intervention difficult. Finally, there is the possibility of response bias among both teachers and students, particularly concerning their perceptions and experiences. Participants who were already aligned or familiar with one teaching method (e.g., preferring holistic over aspect-based, or vice versa) may have provided biased responses during interviews and surveys. Such alignment could have influenced their evaluations of effectiveness, independent of objective performance outcomes.

1.10 Operational Definition of Terms

Holistic Teaching Approach: *Refers to a teaching methodology that integrates various scientific disciplines (physics, chemistry, and biology) into a unified* *framework, emphasizing interdisciplinary connections and fostering a comprehensive understanding of scientific concepts.*

Aspects-Based Teaching Approach: *Refers to a teaching method where each scientific discipline (physics, chemistry, or biology) is taught separately, allowing for a more focused and in-depth exploration of subject-specific content.*

Integrated Science: A core subject in the Ghanaian senior high school curriculum that combines physics, chemistry, and biology to provide students with a broad understanding of scientific principles and their applications.

Competency-Based Curriculum: An educational framework introduced by the Ghanaian Ministry of Education in 2019, which emphasizes the acquisition of skills, knowledge, and attitudes necessary for solving real-world problems and achieving academic success.

Student Engagement: The degree to which students participate actively in the learning process, demonstrating interest, motivation, and involvement in classroom activities.

Academic Performance: The measurable outcomes of students' learning, often evaluated through tests, assignments, and overall grades

1.11 Organization of the Study

The study was organized into five chapters to systematically explore the comparative effectiveness of holistic and aspect-based teaching of Integrated Science in Ghana. Chapter one introduces the background of the study, outlining the research problem. It also states the research objectives, questions, significance of the study's findings, Limitation and the delimitations of the study.

Chapter two presents a review of relevant literature, examining previous research on Integrated Science education, the theoretical foundations of holistic and aspect-based teaching, and the context of science education in Ghana. This chapter aims to provide a comprehensive understanding of the existing knowledge and gaps in the field.

Chapter three describes the research methodology, detailing the design, sampling techniques, data collection methods, and analytical procedures used in the study. This chapter ensures the transparency and replicability of the research process.

Chapter four focuses on the presentation and analysis of the data collected. It compares the effectiveness of holistic and aspect-based teaching approaches using various metrics, including student performance, engagement, and comprehension. The findings are discussed in relation to the research questions and objectives.

Chapter five concludes the study by summarizing the key findings, discussing their implications for Integrated Science education in Ghana, and providing recommendations for educators, policymakers, and future research. This chapter also reflects on the study's limitations and suggests areas for further investigation.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.0 Overview

This chapter reviews literature and studies related to the comparative analysis of holistic and aspects-based teaching in Integrated Science. It begins by discussing the theoretical frameworks that underpin the study, providing a foundation for understanding the principles guiding both teaching approaches. The review then examines a historical overview of integrated science education in Ghana, the impact of these methods on students' academic performance, shedding light on their effectiveness in enhancing learning outcomes. Following this, the chapter explores teachers' perspectives and experiences, focusing on their implementation challenges, strategies, and successes with holistic and aspects-based teaching. Students' perceptions of these methods are then analyzed, emphasizing their engagement, preferences, and attitudes. Lastly, the chapter reviews empirical research on teaching methodologies, identifying the opportunities and challenges they present within Integrated Science education.

2.1 Theoretical Framework

2.1.1 Interdisciplinary Learning Frameworks

Interdisciplinary learning frameworks emphasize integrating concepts, knowledge, and methods from multiple disciplines to provide students with a holistic understanding of complex issues. These frameworks, including the Taba Model of Curriculum Development, Bruner's Spiral Curriculum, the STEAM framework, Inquiry-Based Learning, the Understanding by Design (UbD) Framework, and the Transdisciplinary Approach, aim to foster critical thinking, collaboration, and problem-solving skills. Hilda Taba, a key proponent of the Taba Model in the 1960s, developed a teacher-centered curriculum design approach that emphasized inquiry-based and problem-centered learning (Taba, 1962). Jerome Bruner introduced the Spiral Curriculum in 1960, rooted in constructivist theory, which revisits interdisciplinary themes with increasing complexity to deepen understanding (Bruner, 1960). The STEAM framework, introduced by Georgette Yakman in the early 2000s, integrates arts into STEM (Science, Technology, Engineering, Mathematics), emphasizing creativity alongside technical skills (Yakman, 2008). Inquiry-Based Learning, championed by John Dewey and later supported by scholars like Barron and Darling-Hammond, prioritizes student-driven exploration to develop critical thinking (Dewey, 1938; Barron & Darling-Hammond, 2008). Understanding by Design (UbD), developed by Grant Wiggins and Jay McTighe in 1998, emphasizes backward curriculum design to focus on big ideas and essential questions across disciplines (Wiggins & McTighe, 1998). Finally, Basarab Nicolescu's work on the Transdisciplinary Approach extends beyond academic boundaries, integrating societal and cultural perspectives into educational practices (Nicolescu, 2002).

These frameworks share common assumptions. They posit that meaningful learning occurs when students connect ideas across disciplines and engage in inquiry-driven exploration. The Taba Model assumes that teacher-designed, problem-centered curricula align better with students' needs (Taba, 1962). The Spiral Curriculum suggests that revisiting core concepts fosters retention and deeper understanding (Bruner, 1960). The STEAM framework assumes that creativity and innovation are vital for solving modern challenges, integrating arts to enrich the technical and analytical aspects of STEM (Yakman, 2008). Inquiry-Based Learning relies on the belief that student curiosity is the most effective driver of engagement and understanding (Dewey, 1938). UbD assumes that focusing on enduring understandings and backward design ensures coherence and alignment in teaching (Wiggins & McTighe, 1998). The Transdisciplinary Approach presumes that real-world problems require solutions beyond traditional academic disciplines, involving external stakeholders for enriched learning outcomes (Nicolescu, 2002).

These frameworks, while united in their interdisciplinary emphasis, differ in scope and implementation. The Taba Model and UbD Framework prioritize curriculum design but diverge in their approaches; the Taba Model uses a bottom-up process, while UbD employs a top-down approach (Taba, 1962; Wiggins & McTighe, 1998). Bruner's Spiral Curriculum aligns with the STEAM framework in its iterative learning emphasis but does not explicitly incorporate creative or artistic elements (Bruner, 1960; Yakman, 2008). Inquiry-Based Learning and the Transdisciplinary Approach both encourage exploration but differ in application; the former remains within educational settings, while the latter extends learning into real-world contexts (Dewey, 1938; Nicolescu, 2002).

Despite their strengths, each framework has limitations. The Taba Model, while adaptable, is time-intensive for teachers and lacks standardization (Taba, 1962). The Spiral Curriculum ensures knowledge retention but requires meticulous planning (Bruner, 1960). STEAM promotes creativity but may face implementation challenges, particularly where arts training for teachers is insufficient (Yakman, 2008). Inquiry-Based learning effectively engages students but can be challenging in large or under-resourced classrooms (Barron & Darling-Hammond, 2008). UbD ensures coherence in lesson planning but may limit spontaneous learning opportunities (Wiggins & McTighe, 1998). The Transdisciplinary Approach offers practical solutions to real-world issues but often requires extensive resources and collaboration, which may not always be feasible (Nicolescu, 2002).

The interdisciplinary learning framework is considered the most suitable for this study because it provides a comprehensive lens through which to analyze and compare holistic and aspects-based teaching approaches in Integrated Science. This framework emphasizes the integration of diverse concepts and methods, aligning well with the study's objectives, which involve assessing academic performance, teachers' experiences, and students' perceptions. Holistic teaching, characterized by its emphasis on interconnected learning, resonates with the interdisciplinary framework by promoting the synthesis of knowledge across different science domains. Similarly, aspects-based teaching, which focuses on breaking down content into discrete, manageable components, can be evaluated within this framework to understand its impact on structured and focused learning (Chakera et al., 2020).

For the first objective, the interdisciplinary framework enables a nuanced examination of how each teaching method fosters cognitive connections across scientific disciplines and impacts academic performance. Holistic teaching aligns with interdisciplinary principles by promoting an integrative understanding of science, while aspects-based teaching benefits from the framework's emphasis on targeted knowledge building. For the second objective, which explores teachers' perspectives, the framework offers a robust structure to analyze how educators navigate the complexities of implementing both methods. It highlights how teachers integrate curriculum content, pedagogical strategies, and real-world applications, reflecting the strengths and challenges inherent in both approaches. For the third objective, which examines students' perceptions, the interdisciplinary framework helps assess how these teaching methods influence students' engagement, critical thinking, and overall understanding of Integrated Science as a cohesive subject (National Research Council (2012).

Furthermore, the framework's focus on collaboration and real-world problem-solving is directly applicable to Integrated Science, a subject inherently interdisciplinary in nature. It allows the study to critically evaluate how well each teaching approach prepares students for complex, real-life scientific challenges. The framework also facilitates a comparative analysis by providing a consistent evaluative basis for both holistic and aspects-based methods, making it instrumental in addressing the study's objectives comprehensively. Thus, its adaptability, focus on integration, and relevance to both pedagogical and learner-centered aspects make the interdisciplinary learning framework the most suitable choice for guiding this research.

2.2 Historical Overview of Integrated Science Education in Ghana

Integrated Science education in Ghana has undergone significant transformations since its introduction into the senior high school curriculum. The evolution of the subject reflects broader shifts in the country's educational policies, aimed at fostering scientific literacy and equipping students with the skills necessary to address societal challenges.

The origins of Integrated Science in Ghana trace back to the educational reforms of the 1980s, which emphasized a more holistic approach to science education (Akyeampong, 2010). Before this period, science subjects were taught as distinct disciplines physics, chemistry, and biology. However, this approach posed challenges for both teachers and students, as it required specialized expertise in each subject area and often created fragmented learning experiences for students. In response, the

Ghanaian government introduced Integrated Science as part of a broader initiative to streamline science education and ensure students developed a comprehensive understanding of scientific concepts.

The 1987 educational reforms marked a turning point in the development of Integrated Science. These reforms, initiated under the Education Reform Program (ERP), sought to address the gaps in Ghana's educational system by making science education more relevant and accessible to all students (Ghana Ministry of Education, 1987). Integrated Science was designed to merge the core elements of physics, chemistry, and biology into a single subject, providing students with a cohesive understanding of science. This approach was intended to eliminate redundancies in the curriculum and promote interdisciplinary thinking.

The introduction of Integrated Science also aligned with Ghana's national development goals, which emphasized the need for a scientifically literate workforce to drive technological innovation and economic growth (Ghana Vision 2020, 1995). By integrating scientific disciplines, policymakers aimed to foster problem-solving skills and critical thinking among students, enabling them to apply scientific knowledge to real-world issues. Integrated Science was also made a core subject in senior high schools, ensuring that all students, regardless of their future career paths, received foundational training in science.

Over the years, subsequent educational reforms have further shaped the structure and delivery of Integrated Science in Ghana. The 2007 educational reform introduced a new curriculum framework that emphasized practical and competency-based learning. This reform was informed by global trends in science education, which prioritized hands-on experiments and inquiry-based learning (Anamuah-Mensah et al., 2007).

The Integrated Science curriculum was revised to include more practical activities, allowing students to actively engage with scientific concepts and develop essential laboratory skills.

In 2019, the National Council for Curriculum and Assessment (NaCCA) introduced competency-based education reforms aimed at aligning Ghana's educational system with international standards. These reforms reinforced the interdisciplinary nature of Integrated Science, emphasizing the connections between scientific disciplines and their applications in everyday life (Ministry of Education, 2019). The updated curriculum also integrated themes such as environmental sustainability, technology, and innovation, reflecting the growing importance of these areas in national development.

Despite these advancements, the implementation of Integrated Science in Ghanaian schools has faced several challenges. Resource constraints, such as inadequate laboratory facilities and teaching materials, have limited the effectiveness of the curriculum. Many schools, particularly in rural areas, lack the infrastructure necessary for practical experiments, which are essential for reinforcing theoretical concepts (Buabeng et al., 2015). Additionally, the shortage of qualified science teachers remains a significant barrier, with many teachers lacking the interdisciplinary expertise required to effectively teach Integrated Science (Adu-Gyamfi & Ampiah, 2016).

The evolution of Integrated Science in Ghana also reflects ongoing efforts to address students' underperformance in science-related subjects. International assessments, such as the Trends in International Mathematics and Science Study (TIMSS), have consistently highlighted gaps in Ghanaian students' understanding of science concepts

(Mereku & Anumel, 2011). These findings have prompted policymakers and educators to explore innovative teaching approaches, including the holistic and aspect-based methods, to enhance learning outcomes.

Today, Integrated Science continues to play a central role in Ghana’s senior high school curriculum. It serves as a foundational subject for students pursuing careers in science, technology, engineering, and mathematics (STEM), as well as those in other fields. The interdisciplinary approach of Integrated Science reflects the dynamic and interconnected nature of scientific knowledge, preparing students to navigate complex global challenges.

2.3 Holistic Teaching Approach (HTA)

The holistic teaching approach, particularly in Integrated Science, emphasizes the interconnectedness of various scientific disciplines and the need to address the whole learner rather than focusing solely on isolated areas of knowledge. According to Verna (2020), this approach is rooted in the belief that education should not only impart cognitive knowledge but also foster emotional, social, and ethical development. Verna argues that this approach nurtures well-rounded individuals capable of critical thinking and problem-solving in complex environments. By integrating multiple subjects like biology, chemistry, and physics, holistic teaching provides students with a comprehensive understanding of scientific concepts and their real-world applications (Karampelas, 2019).

One of the core principles of HTA is the recognition of the learner's diverse needs and learning styles. Taglialatela (2023) posits that effective education must cater to the individual differences among students, promoting a supportive and engaging learning environment. Similarly, Yu (2023) emphasizes that employing diverse teaching methods and resources can address the unique preferences of each student, thereby enhancing their learning experiences and outcomes. Methods such as hands-on activities, collaborative projects, and technology-enhanced learning can foster deeper engagement and understanding of scientific concepts (Wheaton & Young, 2019).

Furthermore, HTA encourages the development of critical thinking and problem-solving skills through experiential learning. Harichandran (2018) suggests that this approach enables students to apply their knowledge in practical contexts, reinforcing their understanding and retention of scientific principles. Saleem et al. (2022) highlight that project-based learning, in particular, not only enhances students' scientific knowledge but also cultivates vital skills such as teamwork, communication, and adaptability. According to Müller et al. (2008), such experiences are crucial for preparing students for the complexities of modern scientific challenges, as they learn to navigate and synthesize information from various sources and disciplines.

A significant aspect of HTA in Integrated Science is its emphasis on the ethical and social dimensions of science education. Saleem et al. (2022) argue that by integrating discussions on sustainability, social responsibility, and ethical considerations into the curriculum, educators can foster a sense of civic responsibility among students. Borg et al. (2012) further contend that this focus is particularly relevant in Integrated Science, where students can explore the broader implications of scientific advancements on society and the environment. They suggest that discussions on climate change, resource management, and public health can help students understand the impact of scientific knowledge and their responsibility as informed citizens.

In addition, HTA promotes a collaborative learning environment that values the contributions of all students. Taglialatela (2023) posits that this collaborative approach not only enhances peer learning but also encourages respect for diverse perspectives and experiences. Verna (2020) emphasizes that fostering a classroom culture that values collaboration helps students develop essential interpersonal skills, which are vital for success both academically and professionally. By encouraging teamwork and collective problem-solving, educators can prepare students for collaborative work in diverse real-world contexts.

Moreover, the HTA in Integrated Science incorporates the use of technology to enhance the learning experience. According to Wheaton and Young (2019), technology offers students' access to vast resources, facilitates collaboration, and enables innovative teaching methods. Yu (2023) highlights that blended learning models, which combine online and face-to-face instruction, provide flexibility and cater to diverse learning preferences. Such models promote a more personalized learning experience, enabling students to engage with content at their own pace and in ways that best suit their learning style.

Furthermore, HTA encourages educators to reflect on their practices and continuously adapt to meet the evolving needs of their students. Harichandran (2018) argues that reflective practice is crucial for fostering an inclusive and responsive learning environment that prioritizes student engagement and success. Müller et al. (2008) suggest that by regularly assessing the effectiveness of teaching strategies and seeking feedback from students, educators can make informed adjustments that enhance the overall learning experience. Reflective teaching practices ensure that educators remain responsive to the needs of their students, creating a dynamic and effective learning environment.

2.3.1 Benefits and Evidence of its Effectiveness in Science Classroom

The effectiveness of the HTA has been substantiated by numerous studies, highlighting its benefits in fostering comprehensive skill development, promoting student engagement, and improving overall educational experiences. One of the primary benefits of a holistic teaching approach is its ability to bridge the gap between theoretical knowledge and practical application. Harichandran (2018) notes that holistic teaching allows students to gain a comprehensive view of subjects, thereby connecting academic knowledge with real-life practices. According to Harichandran, this connection is crucial in science education, where understanding the application of concepts can significantly enhance learning outcomes.

Koutsopoulos (2019) argues that adopting an integrated-holistic approach is essential for teaching science-related disciplines effectively. He further emphasizes that this approach aligns educational practices with contemporary needs and societal challenges. This alignment, as Koutsopoulos suggests, not only makes learning more relevant but also prepares students to tackle real-world problems, ensuring that education remains both practical and timely in addressing societal issues.

Evidence supporting the effectiveness of a holistic approach is found in various studies that demonstrate improved student outcomes. Drake and Reid (2018) assert that integrated curricula can significantly enhance 21st-century capabilities such as critical thinking and collaboration. According to the authors, these capabilities are essential for success in modern society, suggesting that integrated curricula help develop essential skills that extend beyond academic achievement. These skills, they argue, are crucial for students' future success in a rapidly evolving, interconnected world.

Moreover, Dios et al. (2020) highlight how curricular integration, particularly through citizen science initiatives, fosters scientific literacy and encourages student engagement with sustainable development goals. The authors contend that curricular integration not only enhances students' theoretical knowledge but also promotes active learning, where students engage with real-world problems in a meaningful way. This integration, they argue, helps deepen students' understanding of scientific principles and their applications to societal issues, encouraging them to become more informed and active citizens.

In addition, holistic teaching promotes collaboration among educators, which is vital for successful implementation. Roehrig et al. (2012) emphasize that effective STEM integration often requires collaboration between mathematics and science teachers. They argue that co-teaching can enhance the learning experience by allowing educators to share expertise, resources, and teaching strategies, ultimately benefiting students. They suggest that such collaboration leads to a more cohesive and integrated curriculum, enabling students to connect concepts across disciplines more easily.

Furthermore, the integration of different subjects in a holistic approach results in more engaging and meaningful learning experiences. Roehrig et al. (2012) also highlight that collaborative efforts among educators create a professional learning community, which enriches students' learning by providing them with a dynamic and interconnected educational experience. This collaborative teaching environment, as they point out, helps foster both academic and professional growth, benefiting students in the long term.

While the HTA has demonstrated significant potential in enhancing student engagement and learning outcomes, the challenges associated with its implementation should not be overlooked. According to Karampelas (2019), teachers face difficulties in integrating science with other subjects, attributing these challenges to curriculum constraints and a lack of support. Chanifah et al. (2021) further argue that such barriers can hinder the effective adoption of a holistic teaching approach, underscoring the need for robust policy frameworks and professional development opportunities for educators. Without sufficient support, teachers may struggle to contextualize scientific concepts within an integrated curriculum, limiting the effectiveness of the holistic approach in fostering interdisciplinary connections. Thus, addressing these challenges is crucial for maximizing the benefits of holistic education.

In addition to fostering engagement and deeper understanding, a HTA also contributes significantly to the development of scientific literacy. Prachagool and Nuangchalerm (2019) emphasize the importance of integrating instructional strategies that reflect the nature of science, which is essential for fostering a comprehensive understanding of scientific concepts. By incorporating real-world applications and interdisciplinary connections, educators can help students develop a more nuanced understanding of science and its role in society. As noted by Mutseekwa (2021), scientific literacy is increasingly critical in an era where informed decision-making and civic engagement are integral to addressing global challenges. The holistic approach, therefore, plays a key role in equipping students with the knowledge and skills necessary to navigate complex scientific issues in a societal context.

Moreover, the HTA aligns with contemporary educational paradigms that prioritize student-centered learning. The integration of various disciplines encourages students to take ownership of their learning, fostering a sense of agency and responsibility.

Gilbert and Byers (2017) suggest that traditional science education often emphasizes rote memorization of isolated facts, which can hinder students' ability to engage in scientific inquiry. In contrast, the holistic approach promotes inquiry-based learning, where students actively explore scientific concepts in a meaningful and connected manner. This shift from passive to active learning not only enhances students' understanding but also encourages critical thinking and problem-solving skills that are essential in today's rapidly evolving world.

Another key aspect of the HTA is the role of community involvement in supporting educational initiatives. Moslimany (2017) highlights that schools that successfully integrate holistic practices often benefit from strong partnerships with parents and local organizations, which provide additional resources and support for students. According to Gilbert and Byers (2017), such community engagement enriches the educational experience and helps foster a sense of belonging and responsibility among students. When schools engage with the wider community, students are exposed to diverse perspectives and experiences that enhance their learning. This involvement not only strengthens the connection between school and community but also helps students see the real-world applications of their learning, further motivating them to succeed.

2.3.2 Challenges in Implementing Holistic Teaching Approach (HTA)

Implementing the Holistic Teaching Approach (HTA) presents several challenges that educators must navigate in order to fully realize its intended benefits. One of the primary obstacles is the existing curriculum structure, which often prioritizes disciplinary silos over interdisciplinary connections. According to Karampelas (2019), many educational systems remain entrenched in traditional methods that compartmentalize subjects, making it difficult for educators to adopt a holistic perspective in their teaching practices. He further notes that although there are suggestions for integrating science with other subjects such as language and mathematics, the curriculum itself often lacks the necessary flexibility to support such integration. This rigidity leads to a fragmented learning experience for students, which undermines the holistic principles that HTA aims to promote.

In addition to curriculum limitations, assessment practices further complicate the implementation of HTA. Chan and Lee (2021) argue that the absence of systematic assessment approaches for holistic competencies can leave students unclear about expectations, which ultimately hinders their learning progress. Traditional assessment methods, such as standardized testing, tend to focus on isolated academic achievements, which fails to capture the broader, more diverse nature of student learning in a holistic framework. As a result, disconnection arises between teaching methods and assessment strategies, leading to challenges in fully embracing HTA. Educators, feeling pressured to conform to standardized assessment criteria, may hesitate to implement holistic educational practices, as they do not align with traditional assessment standards (Shepard et al., 2018).

Furthermore, the professional development of educators plays a crucial role in the effective implementation of HTA. Many teachers have not received adequate training in interdisciplinary teaching methods, which can result in a lack of confidence in their ability to deliver a holistic curriculum (Daú et al., 2023). Wisthout sufficient training in how to integrate various subjects meaningfully, educators may struggle to apply the principles of HTA in the classroom. Goh (2024) emphasizes that insufficient resources and support for teachers exacerbate the challenges of incorporating holistic approaches into existing educational frameworks. If educators are not equipped with the necessary tools and ongoing professional development, they may fail to implement HTA in a transformative way, resulting in a superficial application of its principles rather than fostering deep and meaningful learning experiences for students (Darling-Hammond et al., 2017).

Another significant challenge in implementing the Holistic Teaching Approach (HTA) is the need for collaboration among educators across different disciplines. Effective HTA requires teachers to work together to design and deliver integrated lessons that draw on multiple subject areas. According to Koutsopoulos (2019), this collaboration is essential for creating an interdisciplinary learning environment that reflects the interconnectedness of knowledge. However, as Rafiq (2024) points out, the traditional structure of educational institutions often fosters competition rather than collaboration among educators. This institutional culture can make it difficult for teachers to develop cohesive interdisciplinary lessons, limiting students' ability to experience the full benefits of a holistic education. Without collaboration, students may miss out on opportunities to engage with content in a more meaningful way, as they may not perceive the connections between different knowledge areas that HTA seeks to promote.

The integration of technology into the HTA framework also presents its own set of challenges. While technology has the potential to enhance interdisciplinary learning by providing access to diverse resources and facilitating collaboration, it can also create barriers if not implemented thoughtfully. Li (2024) discusses how technology can be leveraged to support interdisciplinary integration in STEAM (Science, Technology, Engineering, Arts, and Mathematics) education. However, Li (2024) emphasizes the importance of strategic planning in overcoming potential implementation challenges. Without careful consideration of how technology is used, educators may inadvertently reinforce existing subject silos rather than promote a holistic approach to learning. Therefore, the successful use of technology in HTA requires careful integration to align with the broader goals of interconnected and interdisciplinary education.

Cultural factors can also significantly influence the effectiveness of HTA. In some educational contexts, traditional views on education may prioritize rote memorization and individual achievement over collaborative and integrative learning experiences. Moslimany (2024) highlights that cultural resistance to change can pose a major barrier to adopting HTA, as educators may be hesitant to shift away from familiar, traditional methods. This resistance can be a significant challenge when trying to implement a more collaborative, student-centered, and holistic approach to teaching. The challenge, therefore, lies in fostering a cultural shift within educational institutions that values and supports holistic methods of teaching and learning.

Finally, the varying levels of student readiness and engagement also pose challenges for HTA implementation. As Koutsopoulos (2019) notes, students come to the classroom with diverse backgrounds, experiences, and learning styles, which can impact their ability to engage with integrated science content. Educators must be prepared to differentiate instruction and provide the necessary support to ensure that all students can benefit from a holistic learning experience. This requires a deep understanding of student needs and the flexibility to adapt teaching strategies to meet those needs, a task that can be daunting for many educators. Therefore, educators must be adequately supported and equipped with strategies to differentiate instruction effectively in the context of HTA.

2.4 Aspect-Based Teaching Approach

The Aspect-Based Teaching Approach (ABTA) is a pedagogical framework that emphasizes the evaluation and enhancement of teaching practices through the analysis of specific aspects of instruction. This approach is grounded in the principles of learner-centered education, focusing on understanding and improving the various dimensions of teaching that impact student learning outcomes. The ABTA is characterized by its systematic examination of teaching elements, such as instructional strategies, classroom environment, and student engagement, to foster a more effective learning experience (Bhowmik, 2023).

One of the core principles of the Aspect-Based Teaching Approach (ABTA) is recognizing the diverse preferences and needs of students. According to Kuzmanovic et al. (2012), students' evaluations of teaching often reflect their individual learning preferences, which can vary significantly across different contexts. This heterogeneity necessitates a tailored approach to teaching that considers the unique aspects of each learner's experience. By employing aspect-based evaluations, educators can gain insights into which specific elements of their teaching resonate with students, allowing for more targeted improvements (Bhowmik, 2023).

Furthermore, the ABTA aligns with the Production-Oriented Approach (POA), which emphasizes integrating teaching and learning processes to enhance language acquisition and other educational outcomes. The POA posits that effective teaching should not only focus on input but also on the output generated by students, creating a more dynamic learning environment (Sun, 2020). This principle is echoed in the

ABTA, where the focus on specific teaching aspects facilitates a deeper understanding of how instructional practices influence student performance and engagement, as Liu (2018) argues.

In the context of higher education, the ABTA has been shown to improve teaching effectiveness by providing a structured framework for evaluating and refining pedagogical practices. According to Bhowmik (2023), using aspect-based evaluations can lead to significant enhancements in teaching quality, as educators become more aware of the specific factors that contribute to successful learning outcomes. This is particularly relevant in disciplines such as technical translation, where methodological considerations play a crucial role in shaping the learning experience (Pop, 2017).

Moreover, the ABTA encourages reflective teaching practices, where educators critically analyze their own beliefs and strategies in light of student feedback. Singhasiri (2011) emphasizes that this reflective stance is essential for fostering a culture of continuous improvement within educational institutions. By systematically examining the aspects of their teaching, educators can identify areas for growth and implement changes that align with student needs and preferences (Wulandari, 2019).

The implementation of the ABTA also involves the use of various assessment tools and methodologies to gather data on teaching effectiveness. According to Marsh et al. (2011), student ratings and feedback can be utilized to benchmark teaching practices against established standards, providing valuable insights into the strengths and weaknesses of instructional approaches. This data-driven approach not only enhances accountability but also empowers educators to make informed decisions about their teaching strategies (Kuzmanovic et al., 2012).

In addition to its focus on evaluation and improvement, the ABTA promotes collaboration among educators. By sharing insights and experiences related to specific teaching aspects, educators can collectively enhance their practices and foster a supportive learning community (Biletska et al., 2021). This collaborative approach is particularly beneficial in higher education settings, where interdisciplinary teaching and learning are increasingly emphasized (Snyman & Kroon, 2005).

The ABTA also recognizes the importance of aligning teaching practices with broader educational goals and standards. By focusing on specific aspects of teaching, educators can ensure that their practices are not only effective but also relevant to the evolving needs of students and the demands of the job market (Liu, 2018). This alignment is crucial for preparing students for success in their future careers, as it equips them with the skills and knowledge necessary to thrive in a competitive environment (Liu et al., 2023). As educational contexts continue to evolve, the ABTA provides a valuable tool for educators seeking to improve their practices and better serve their students.

2.4.1 Benefits and Evidence of its Effectiveness in Science Classroom

The Aspect-Based Teaching Approach (ABTA) has gained traction in science education as a method that emphasizes specific aspects of learning and teaching, ultimately leading to improved educational outcomes. According to Cairns (2019), this approach is particularly beneficial in fostering inquiry-based learning, enhancing student engagement, and accommodating diverse learning needs in the science classroom.

One of the most significant benefits of the ABTA is its promotion of inquiry-based learning, which encourages students to actively engage with scientific concepts. Research indicates that inquiry-based instructional methods lead to higher student achievement compared to traditional teaching approaches. For example, a study analyzing various instructional practices found that inquiry-based methods significantly enhance students' understanding and retention of scientific knowledge (Cairns, 2019). Kinyota (2020) argues that inquiry-based science teaching (IBST) is crucial for improving STEM education outcomes. Furthermore, the integration of inquiry-based practices in science education has been shown to foster critical thinking skills, which are essential for scientific literacy (Cairns, 2019).

In addition to promoting inquiry, the ABTA facilitates collaborative learning environments, which are vital for effective science education. Collaborative learning has been linked to improved academic performance and deeper understanding of complex scientific concepts. According to a systematic review of empirical studies, collaborative instructional strategies significantly enhance students' learning outcomes in science (Lewis et al., 2014). This is particularly relevant in the context of the ABTA, which encourages teachers to create inclusive classroom environments where students feel comfortable sharing ideas and engaging in discussions, as noted (Fazio et al. ,2020). Such collaborative settings not only enhance student engagement but also help develop essential social skills necessary for scientific discourse.

Moreover, the ABTA is effective in addressing the diverse learning needs of students in the science classroom. By focusing on specific aspects of learning, educators can tailor their instruction to accommodate different learning styles and backgrounds. According to Nadelson et al. (2013), the integration of transdisciplinary teaching approaches allows educators to connect scientific concepts with real-world applications, making learning more relevant and engaging for students. This adaptability is crucial, as it enables teachers to meet the varying needs of their students, thereby fostering a more inclusive learning environment.

The ABTA also enhances students' critical thinking and problem-solving skills, which are essential components of scientific education. The emphasis on inquiry and exploration encourages students to analyze data, draw conclusions, and apply their knowledge to real-world problems. Cairns (2019) argues that students who engage in inquiry-based learning develop stronger critical thinking skills compared to those who receive traditional instruction. This is particularly important in science education, where the ability to think critically and solve problems is paramount for success.

Furthermore, the ABTA has been associated with increased student motivation and engagement in science learning. According to Brew (2012), when students are actively involved in their learning process, they are more likely to be motivated and invested in their education. A study examining the impact of various teaching methods found that students who participated in inquiry-based learning reported higher levels of engagement and satisfaction with their learning experience. This increased motivation can lead to better academic performance and a greater interest in pursuing science-related fields in the future.

The implementation of the ABTA aligns with contemporary educational reforms that emphasize evidence-based practices in teaching. Cairns (2019) highlights the need for research-supported teaching methods in various educational policies, advocating for effective instructional strategies to improve student outcomes. The ABTA, with its focus on inquiry, collaboration, and critical thinking, is well-positioned to meet these demands and contribute to the development of a more effective science curriculum.

Additionally, the ABTA supports the integration of research and teaching, which has been shown to enhance the quality of education. Brew (2012) argues that a stronger relationship between research and teaching can lead to a culture of inquiry that benefits both educators and students. By incorporating research-based practices into the classroom, teachers can foster a more dynamic learning environment that encourages students to engage with scientific concepts critically and creatively (Roudaut, 2019).

2.4.2 Challenges in Implementing Aspect-Based Teaching Approach (ABTA)

The Aspect-Based Teaching Approach (ABTA) has emerged as a promising pedagogical strategy aimed at enhancing student engagement and learning outcomes by focusing on specific aspects of a subject matter. However, its implementation is fraught with challenges that educators must navigate to ensure its effectiveness. One of the primary challenges in implementing the ABTA is the tendency of teachers to revert to traditional, teacher-centered pedagogies when faced with difficulties in managing student engagement and participation. Tidemand and Nielsen (2016) argue that teachers often resort to factual, teacher-centered activities as a coping mechanism in response to the complexities of facilitating open-ended discussions on socioscientific issues. This tendency can undermine the potential of ABTA, which relies on student-centered learning to foster critical thinking and engagement. Similarly, Ibrahim and Mahmud (2020) highlight that while teachers may possess knowledge of inquiry-based approaches, their classroom practices often do not reflect this understanding, indicating a disconnect between theoretical knowledge and practical application.

Moreover, teachers' beliefs about the nature of inquiry and student-centered learning significantly influence their instructional practices. According to Saad and Boujaoude (2012), many teachers classify their activities as "student-centered" without fully embracing inquiry-based methodologies. This misalignment suggests that teachers may lack a deep understanding of how to effectively implement ABTA, leading to superficial engagement with the approach. Furthermore, the integration of sustainability thinking into curricula, as discussed by Sundsbø et al. (2015), presents another layer of complexity. Teachers may struggle to incorporate sustainability concepts into their lessons while adhering to the ABTA framework, particularly if they lack adequate training and resources.

Another significant challenge is the lack of adequate professional development opportunities for teachers to enhance their understanding and implementation of ABTA. According to Karampelas (2018), effective teaching of the nature of science (NOS) requires adherence to specific guidelines that many teachers may not be familiar with. Without proper training, teachers may struggle to implement ABTA effectively, leading to inconsistent educational experiences for students. This is echoed by the findings of Dai et al. (2011), who noted that teachers in China expressed concerns about the practical viability of inquiry-based approaches within their current educational contexts, highlighting the need for targeted professional development.

In addition to professional development, the availability of instructional materials and resources is crucial for the successful implementation of ABTA. The study by

Zhao (2024), illustrates that inadequate resources can hinder teachers' ability to effectively engage students in aspect-based learning. This challenge is compounded by the rapid transition to online learning environments, as noted by Leiba and Gafni (2021), where teachers often lack the necessary pedagogical and technological skills to facilitate effective learning experiences. The COVID-19 pandemic has further exacerbated these issues, as many educators were unprepared for the sudden shift to remote teaching, resulting in a reliance on traditional methods that do not align with the principles of ABTA.

Furthermore, the cultural and social context in which teachers operate can significantly impact their ability to implement ABTA. As highlighted by Faisal and Martin (Faisal & Martin, 2022), teachers' perceptions and attitudes towards socio-scientific issues can shape their instructional practices. In contexts where there is resistance to discussing controversial topics, teachers may avoid incorporating these aspects into their lessons, thereby limiting the effectiveness of ABTA. This is further supported by the findings of Karahan and Roehrig (2018), who found that teachers' epistemological beliefs about science and socioscientific issues influenced their instructional choices, often leading to a focus on scientific data rather than the social implications of these issues. Moreover, the interplay between teachers' knowledge, beliefs, and classroom practices presents a significant challenge in the implementation of ABTA. As noted by Hugerat et al. (Hugerat et al., 2015), teachers must possess not only content knowledge but also pedagogical content knowledge to effectively engage students in aspect-based learning. The lack of alignment between teachers' beliefs about inquiry and their actual practices can create barriers to the successful implementation of ABTA. This disconnect can result in a failure to fully engage students in meaningful learning experiences, as teachers may inadvertently prioritize content delivery over student engagement.

2.5 Comparative Effect of Holistic and Aspects-Based Teaching on Students' Academic Performance in Integrated Science

The comparison of HTA and ABTA in the context of Integrated Science education reveals significant differences in their effects on students' academic performance. HTA has been shown to enhance students' academic performance by fostering a more integrated understanding of concepts. For instance, a study by Cornoldi et al. (2015) demonstrated that students who engaged in holistic learning strategies, which included metacognitive training and working memory enhancement, exhibited improved problem-solving abilities in mathematics. This improvement can be extrapolated to Integrated Science contexts as well, suggesting that HTA, which promotes the integration of various knowledge domains, can lead to better academic outcomes.

In contrast, ABTA, which often isolates subjects and concepts, may limit students' ability to see the connections between different areas of knowledge. Research indicates that students in integrated learning environments reported higher levels of understanding and intellectual curiosity. For example, Harichandran (2018) found that 95% of medical students felt that integrated teaching improved their learning skills and clarity of concepts. This highlights the potential shortcomings of ABTA, which may not adequately prepare students for the interdisciplinary nature of real-world scientific problems.

Moreover, HTA has been associated with the development of essential skills beyond mere academic performance. According to Chen (2019), teamwork activities, which are often a component of HTA, significantly enhance leadership skills and self-efficacy among students. These factors, in turn, positively influence their academic performance. This aligns with the findings of Berge et al. (2013), who noted that HTA methods lead to deeper learning experiences and better retention of knowledge among dental students. Such outcomes are critical in Integrated Science, where collaborative problem-solving and critical thinking are essential.

The effectiveness of HTA is further supported by evidence from educational development research, which emphasizes the need for a comprehensive approach to teaching that considers the diverse needs of students. Li et al. (2021) highlighted that holistic teaching designs can transform classroom practices and significantly impact students' learning experiences. This transformation is particularly relevant in Integrated Science, where the integration of various scientific disciplines can enhance students' understanding and application of knowledge.

On the other hand, ABTA may lead to fragmented learning experiences that do not adequately prepare students for the complexities of scientific inquiry. According to Kurniawan (2023), the impact of teaching methods on academic performance is substantial, yet ABTA often fails to engage students fully, resulting in lower performance outcomes. This is particularly concerning in Integrated Science, where the ability to synthesize information from various scientific fields is crucial for success.

Furthermore, studies have shown that HTA not only improves academic performance but also fosters a positive learning environment. For example, research by Morris and Carroll (2016) emphasized that a holistic approach to education encourages a culture of integrity and collaboration among students, which can enhance their overall learning experience. This is particularly relevant in Integrated Science, where collaborative projects and ethical considerations are integral to scientific practice (Morris & Carroll, 2016).

In addition, the integration of technology in HTA has been shown to further enhance student engagement and learning outcomes. Siregar (2023) discussed the application of digital tools in teaching, noting that they improve cognitive abilities and learning outcomes among students. This suggests that holistic approaches that incorporate modern educational technologies can significantly enhance the effectiveness of Integrated Science education.

2.6 Teachers' Perspectives and Experiences with Implementing Holistic And Aspects-Based Teaching of Integrated Science

The implementation of HTA and ABTA in Integrated Science is a diverse endeavor that requires teachers to navigate various pedagogical, curricular, and contextual challenges. Teachers' perspectives and experiences play a crucial role in shaping how these educational strategies are executed in the classroom. Teachers often express a positive attitude towards the integration of various subjects within the science curriculum. For instance, Ampofo and Dickson (2020) found that many science teachers in Ghana hold favorable views on integrating science with social studies, believing that such integration enhances the educational experience by providing a broader context for scientific concepts. This sentiment is echoed in other studies, where teachers recognize the value of interdisciplinary approaches in fostering a more comprehensive understanding of science (Mohammed & Amponsah, 2021). However, the effectiveness of these integrations can be hampered by teachers' specific training in distinct science subjects, which may lead to a reluctance to adopt a more holistic teaching approach (Mohammed & Amponsah, 2021).

Moreover, the experiences of teachers in implementing integrated science curricula are often shaped by their professional development opportunities. According to Pourdavood and Yan (2021), pre-service and in-service teachers frequently report feeling unprepared to teach integrated science due to a lack of content knowledge and pedagogical skills. This gap in preparation can lead to uncertainty in planning and delivering lessons that effectively integrate multiple scientific disciplines (Pourdavood & Yan, 2021). For instance, Pourdavood and Yan (2021) highlighted that many teachers felt vulnerable in their ability to plan and instruct integrated lessons, emphasizing the need for targeted professional development.

The integration of technology into science teaching has also emerged as a significant factor influencing teachers' experiences. A phenomenological study on pre-service teachers revealed that integrating technological applications into science education can enhance teaching effectiveness and engagement ("Integration of Technology into Science Teaching: A Phenomenological Study on the Experiences of the Pre-service Teachers," 2023). Teachers reported that technology not only aids in the delivery of content but also facilitates a more interactive and engaging learning environment for students (Esra et al., 2023). However, the successful incorporation of technology requires adequate training and support, as many teachers may lack confidence in using these tools effectively (Ayodele, 2023).

In addition to technological integration, the pedagogical approach adopted by teachers significantly impacts their experiences with HTA. Inquiry-based instruction, for example, has been shown to enhance student engagement and scientific literacy

(Oliver et al., 2019). However, teachers often face challenges in implementing inquiry-based methods, particularly in contexts where traditional, teacher-centered approaches dominate (Oliver et al., 2019). The need for a shift in pedagogical practices is underscored by the findings of Asiri, who calls for a reevaluation of teacher preparation programs to better align with contemporary science curricula that emphasize inquiry (Asiri, 2018).

Furthermore, the socio-cultural context in which teachers operate plays a crucial role in shaping their perspectives on integrated science teaching. Research by Hsin et al. (2022) highlights that teachers' beliefs about their effectiveness in teaching science are influenced by their understanding of the diverse backgrounds of their students. This understanding can either empower teachers to adopt more inclusive and integrated teaching practices or hinder their ability to connect with students meaningfully (Hsin et al., 2022).

The integration of socio-scientific issues into the curriculum is another aspect that teachers grapple with. Karahan and Roehrig (2017) found that while there is a growing emphasis on addressing socio-scientific issues in science education, many teachers feel ill-equipped to tackle these topics due to a lack of knowledge and experience. This gap in preparedness can lead to missed opportunities for fostering critical thinking and ethical reasoning among students, which are essential components of HTA (Karahan & Roehrig, 2017).

Moreover, the nature of science (NOS) is a critical aspect that teachers must consider when implementing integrated science curricula. Studies have shown that teachers' understanding of NOS significantly influences their teaching practices and the extent to which they integrate scientific concepts with societal issues (García–Carmona, 2021). For instance, García-Carmona's research indicates that many science teacher educators recognize the importance of teaching NOS but often struggle to incorporate it effectively into their curricula (García–Carmona, 2021). This disconnect highlights the need for comprehensive training that equips teachers with the knowledge and skills necessary to teach NOS in a way that resonates with students (García–Carmona, 2021).

2.7 Students' Perceptions of the use of Holistic and Aspects-Based Teaching in Integrated Science

Students' perceptions of HTA and ABTA in Integrated Science are increasingly relevant in contemporary educational discourse. HTA fosters a more comprehensive understanding of scientific concepts by integrating various disciplines and real-world issues. For instance, Kroufek and Nepraš (2023) highlight that a holistic approach can enhance students' attitudes towards complex topics such as climate change, suggesting that this method encourages students to engage with scientific content in a meaningful way. Similarly, Hofstein et al. (2011) argue that recognizing societal issues in science education is essential for fostering scientific literacy, which is often achieved through HTA. This integration not only enhances students' understanding but also promotes their willingness to engage with scientific challenges in their communities.

Moreover, the emotional aspects of learning play a crucial role in students' perceptions of teaching methods. Research indicates that positive academic emotions, which are often fostered in HTA environments, can enhance students' engagement and creativity (Lehtamo et al., 2018). In contrast, negative emotions associated with rigid ABTA methods may lead to disengagement and hinder learning (Lehtamo et al., 2018). Thus, students may perceive HTA as more supportive of their emotional and intellectual development, leading to a preference for this method over traditional, compartmentalized approaches.

The implementation of HTA strategies can also be seen in the context of constructivist learning theories, which emphasize active participation and collaboration among students. Mkimbili (2022) notes that modern teaching methods, including those that are learner-centered, align with constructivist principles, allowing students to construct knowledge through experience and interaction. This approach not only enhances students' understanding of scientific concepts but also fosters critical thinking and problem-solving skills, which are essential in today's complex world.

Furthermore, the integration of design thinking into STEM education exemplifies how HTA can enhance learning experiences. Li et al. (2019) argue that design thinking encourages creativity and innovation, allowing students to engage with scientific concepts in a more integrated manner. This method promotes a deeper understanding of the interconnectedness of scientific disciplines and their applications in real-world contexts, which is a core tenet of HTA.

Students' perceptions of HTA versus ABTA can also be influenced by their experiences in the classroom. For instance, Grooms et al. (2018) found that students' engagement in scientific argumentation is shaped by their understanding of relevant concepts, which is often more effectively developed in HTA environments. This suggests that students may perceive HTA as more conducive to their learning, as it allows for a richer exploration of scientific ideas and encourages collaborative inquiry.

Moreover, the role of personal motivation and interest in science learning cannot be overlooked. Research by Loukomies et al. (2013) indicates that students' motivation towards science is significantly influenced by their learning experiences, which are often more positive in HTA settings. This aligns with the notion that HTA addresses students' personal needs and fosters a more engaging and relevant learning environment, thereby enhancing their overall perception of science education.

In contrast, ABTA may lead to a fragmented understanding of scientific concepts, as it often emphasizes rote memorization and isolated skills. This approach can result in students perceiving science as disconnected from their everyday lives and societal issues. As highlighted by Heras and Ruíz-Mallén (2017), the emerging paradigm of responsible research and innovation in science education emphasizes the need for students to connect scientific knowledge with real-world challenges, which is more effectively achieved through HTA.

Additionally, the challenges associated with implementing learner-centered pedagogy, as discussed by Sikoyo (2010), further illustrate the limitations of ABTA. Teachers often face contextual constraints that hinder the effective implementation of such pedagogies, leading to a reliance on traditional methods that may not resonate with students' perceptions of meaningful learning. This reinforces the idea that HTA, which considers the broader educational context and students' needs, is more likely to foster positive perceptions and outcomes in science education.

2.8 Empirical Studies

2.8.1 Comparative Effect of Holistic and Aspects-Based Teaching on Students' Academic Performance in Integrated Science

Various studies have employed diverse methodologies to explore HTA and ABTA, revealing nuanced insights into how these pedagogical approaches influence learning outcomes. One notable study by Zai et al. (2021) utilized an experimental design to assess the impact of interactive teaching methods on students' science achievement. The researchers compared a control group, which employed traditional teaching methods, with an experimental group that engaged in interactive learning. The findings indicated a significant difference in science achievement, suggesting that interactive and HTA approaches can enhance students' academic performance in science subjects. This aligns with the broader educational literature that emphasizes the effectiveness of student-centered and interactive teaching methods, which are hallmarks of HTA (Kurt, 2024).

In another study, Harahap et al. (2019) examined the effects of blended learning on students' learning achievements and science process skills in a plant tissue culture course. The study employed a mixed-methods approach, combining quantitative assessments of academic performance with qualitative feedback from students. The results demonstrated that the blended learning approach, which integrates both online and face-to-face instruction, significantly improved students' critical thinking skills and overall academic performance compared to traditional methods. This finding supports the notion that HTA strategies, which encompass various learning modalities, can lead to better educational outcomes.

Chien and Liao (2021) conducted research focusing on online HTA, employing a theoretical framework that emphasized collaborative learning and peer interactions. Their study utilized a questionnaire to gather data on students' experiences in a holistic online learning environment. The results indicated that students who participated in this HTA setting exhibited improved engagement and academic performance, underscoring the effectiveness of HTA in fostering a conducive learning atmosphere. This study complements the findings of Zai et al. (2021) and Harahap et al., (2019) reinforcing the idea that HTA can significantly enhance students' academic achievements.

Kurt's (2024) meta-analysis study further corroborates these findings by examining the impact of student-centered teaching methods on academic achievement in life sciences. The analysis concluded that student-centered approaches, which are integral to HTA, positively influence students' attitudes towards the subject matter and enhance their academic performance (Kurt, 2024). This meta-analysis provides a broader context for understanding the effectiveness of HTA strategies across various educational settings.

The research conducted by Iaochite (2023) also contributes to the discourse on HTA by advocating for a more comprehensive understanding of student needs in STEM education. The study emphasizes the importance of adopting HTA strategies that consider students' psychological and emotional well-being, which can significantly impact their academic performance. In contrast, studies focusing on ABTA often highlight the limitations of fragmented educational approaches. For instance, the work of Rahiem (2020) examined the emergency remote learning experiences of university students during the COVID-19 pandemic, revealing that traditional, ABTA methods were less effective in engaging students and promoting meaningful learning. This underscores the need for more integrated and HTA that can adapt to the challenges of modern education.

Moreover, the research by Pan et al. (2010) explored students' perceptions of a holistic care course through cooperative learning. The study utilized a mixed-methods design to assess the effectiveness of HTA in fostering collaborative skills and enhancing learning outcomes. The findings indicated that students who engaged in cooperative learning within a HTA framework reported higher levels of satisfaction and improved academic performance. This further emphasizes the advantages of HTA methodologies over ABTA. In the context of STEM education, the study by Maiorca and Mohr-Schroeder (2020) highlighted the benefits of integrating engineering practices into STEM lesson plans. The research found that students who experienced an integrated curriculum demonstrated improved problem-solving skills and a deeper understanding of scientific concepts, reinforcing the effectiveness of holistic educational strategies. This aligns with the findings from previous studies that advocate for a more cohesive and integrated approach to teaching science.

Furthermore, the work of Kunwar (2024) examined the integration of Gita's educational philosophy into the school curriculum, emphasizing the importance of holistic development in nurturing students' moral and ethical values. The study found that incorporating holistic principles into education significantly enhanced students' overall development and academic performance. This perspective aligns with the broader educational discourse advocating for holistic approaches that transcend traditional subject boundaries.

The comparative analysis of these studies reveals a consistent trend: holistic teaching methodologies tend to yield better academic performance in Integrated Science compared to aspects-based approaches. The integration of various teaching modalities, collaborative learning, and a focus on students' overall well-being are key components that contribute to the effectiveness of holistic education. The evidence from these studies suggests that holistic approaches not only improve academic outcomes but also foster the development of essential skills such as problem-solving, critical thinking, and moral reasoning, which are crucial in today's rapidly evolving educational landscape (Chien and Liao (2021).

2.8.2 Teachers' Perspectives and Experiences with Implementing Holistic and Aspects-Based Teaching of Integrated Science

Stack (2020) conducted an auto-ethnographic study exploring the lived experience of a science educator implementing holistic and integral perspectives in science teaching. The methodology involved reflective self-study over 15 years, analyzing personal teaching practices and transformations. The study aimed to reconcile scientific teaching with holistic educational approaches by integrating interdisciplinary content and personal growth into the science curriculum. Findings indicated that adopting holistic methods led to more engaging and meaningful science education, fostering deeper connections between scientific concepts and students' personal experiences. However, challenges included resistance from traditional educational structures and the need for substantial personal and professional development.

Mafugu et al. (2024) employed a case study design to explore teachers' perceptions of integrative STEM education within life sciences classrooms in South Africa. Data collection methods included face-to-face interviews, analysis of lesson plans, and document examination. The study aimed to understand teachers' comprehension and implementation of integrative STEM approaches, which align with holistic teaching by emphasizing interdisciplinary connections. Findings revealed that teachers had limited understanding of STEM integration, often defaulting to traditional, teacher-centered methods. This approach hindered the promotion of critical thinking among students. The study highlighted the necessity for professional development to enhance teachers' capabilities in implementing integrated STEM education effectively.

Parker et al. (2023) conducted a study examining the challenges faced by Integrated Science teachers in junior high schools. The methodology involved surveys and interviews with science teachers to gather data on their experiences and perceptions. The study explored factors affecting lesson delivery, including resource availability, student attitudes, and instructional methods. Findings indicated that a lack of resources negatively impacted teachers' ability to implement effective science lessons. Additionally, students' negative attitudes towards Integrated Science posed challenges, with perceptions of the subject as difficult leading to disengagement. The study recommended improving resource availability and adopting diverse teaching strategies to enhance student engagement and learning outcomes.

Acheampong et al. (2020) employed a descriptive survey design to investigate senior high school Integrated Science teachers' perceptions of classroom assessment practices in Ghana. Data were collected from 20 teachers using questionnaires to assess their understanding and implementation of various assessment methods. The study focused on teachers' perceptions of assessment as a tool for measuring student learning and guiding instruction. Findings revealed that while teachers had positive perceptions towards classroom assessment, they predominantly associated it with formal tests and showed limited use of diverse assessment methods. The study recommended professional development to broaden teachers' assessment strategies, promoting a more comprehensive evaluation of student learning.

Agyeman and Boateng (2022) conducted a comparative study examining the experiences of Integrated Science teachers implementing both holistic and aspects-based teaching methods. The researchers adopted a case study design, selecting six teachers from three senior high schools in the Greater Accra Region who alternated between the two approaches in their teaching. Data were collected through focus group discussions, classroom observations, and reflective journals kept by the teachers over a semester. The study explored how teachers adapted their teaching strategies to different classroom contexts and student needs. Findings indicated that teachers perceived holistic teaching as more effective for fostering student interest and critical thinking, especially in topics requiring connections across scientific disciplines. Conversely, they found aspects-based teaching better suited for content-heavy topics and exam preparation. Teachers highlighted that the choice of teaching method often depended on external factors, such as the available instructional time, resources, and students' prior knowledge. The study concluded that teachers valued the flexibility of alternating between the two methods but emphasized the need for curriculum reforms to support a more integrated teaching approach.

2.8.3 Students' Perceptions of the use of Holistic and Aspects-Based Teaching in Integrated Science

Akinmoladun and Oluwole (2020) found that Nigerian students appreciated holistic teaching as it allowed them to make connections across different branches of science, leading to improved engagement and motivation. Similarly, Owusu and Darko (2019) noted that Ghanaian students favored holistic teaching for its ability to provide a comprehensive view of science, although some found the breadth of content overwhelming. In contrast, the aspects-based approach, which focuses on specific components of science, was preferred by students who found it more manageable and less cognitively demanding. Studies by Ijeoma and Adewale (2021) and Mensah (2022) in Ghana and Nigeria found that students perceived aspects-based teaching as clearer and more organized, helping them grasp individual concepts more effectively. However, the lack of integration between topics was seen as a limitation, as it sometimes made the subject feel fragmented. Comparative studies by Agyei and Angwafo (2023) and Boadi et al. (2024) highlight that while both teaching methods have their merits, students generally preferred holistic teaching for its ability to engage them in science as a unified field. Nonetheless, those exposed to aspects-based teaching reported feeling more confident in their understanding of specific concepts. These findings suggest that a blended approach that incorporates elements of both holistic and aspects-based methods might be the most effective way to balance content integration with focused, in-depth understanding in Integrated Science education.

A study by Klutse (2021) introduced a novel approach to Integrated Science teaching in a Ghanaian junior high school, emphasizing the incorporation of various learning behaviors acquisition of knowledge, comprehension, application, and experimental skills into lesson planning and delivery. This method aligns with holistic teaching by integrating multiple dimensions of learning. The findings indicated that students developed analytical thinking skills and the capacity to apply knowledge to problem-solving, suggesting the effectiveness of a holistic approach in enhancing student outcomes. Additionally, Rudge (2008) analyzed the pedagogical application of holistic education, focusing on integrating students' personal experiences and interdisciplinary approaches. The study found that holistic methods, which blend content from different disciplines through thematic units and projects, can enhance student engagement and understanding. This contrasts with aspects-based teaching, where subjects are taught separately, potentially limiting interdisciplinary learning.

A study by Baidoo-Anu and Mensah (2018) in the Komenda-Edina-Eguafo-Abrim District of Ghana employed a descriptive survey design to assess junior high school students' perceptions of Integrated Science education. Data were collected through questionnaires administered to a sample of students. The study found that a significant majority of students (78.7%) disagreed with the notion that Integrated Science is irrelevant, boring, and unimportant, indicating a generally positive perception towards the subject. However, 61.9% of respondents perceived Integrated Science as the most difficult core subject, suggesting that while students value the subject, they also find it challenging. In a separate investigation, Baidoo (2023) conducted a study at Potsin T.I. Ahmadiyya Senior High School to explore students' perceptions of assessment for learning in Integrated Science. Using a stratified sampling technique, 215 third-year students were surveyed through questionnaires. The findings revealed that students held positive perceptions of assessment for learning. However, it emerged that students were not assessed adequately in Integrated Science as prescribed in the science syllabus. Additionally, the study indicated that teacher-centered approaches dominated the teaching of Integrated Science, contrary to the student-centered approaches recommended in the syllabus.

2.9 Conceptual Framework

The conceptual framework illustrates the relationships between teaching methods, academic performance, and mediating factors in assessing the effectiveness of holistic and aspects-based teaching in Integrated Science. The independent variables holistic teaching and aspects-based teaching serve as the primary instructional approaches influencing the dependent variable, which is students' academic performance. The study evaluates how each teaching method impacts student outcomes, including comprehension, test scores, and engagement. Two key mediating factors teachers' perspectives and experiences, and students' perceptions play a central role in shaping the relationship between the teaching methods and students' academic performance. Teachers' perspectives and experiences, gathered through interviews and focus groups, provide valuable insights into the practical application of the teaching approaches. These experiences help to identify challenges and benefits associated with holistic and aspects-based teaching, such as resource availability and adaptability to curriculum demands. Similarly, students' perceptions, collected via questionnaires, reveal their engagement and attitudes toward the teaching methods. These perceptions are influenced by how well students connect with and comprehend the content under each approach. Positive perceptions may lead to improved academic performance, as students are more likely to engage deeply with the material. The framework emphasizes that the teaching methods (holistic and aspects-based) interact with the mediating factors (teachers' and students' perceptions), which collectively influence academic performance. This interaction highlights the dynamic nature of the teaching and learning process, showing that the effectiveness of a teaching method is not solely based on the method itself but also on how it is perceived and implemented by educators and learners.

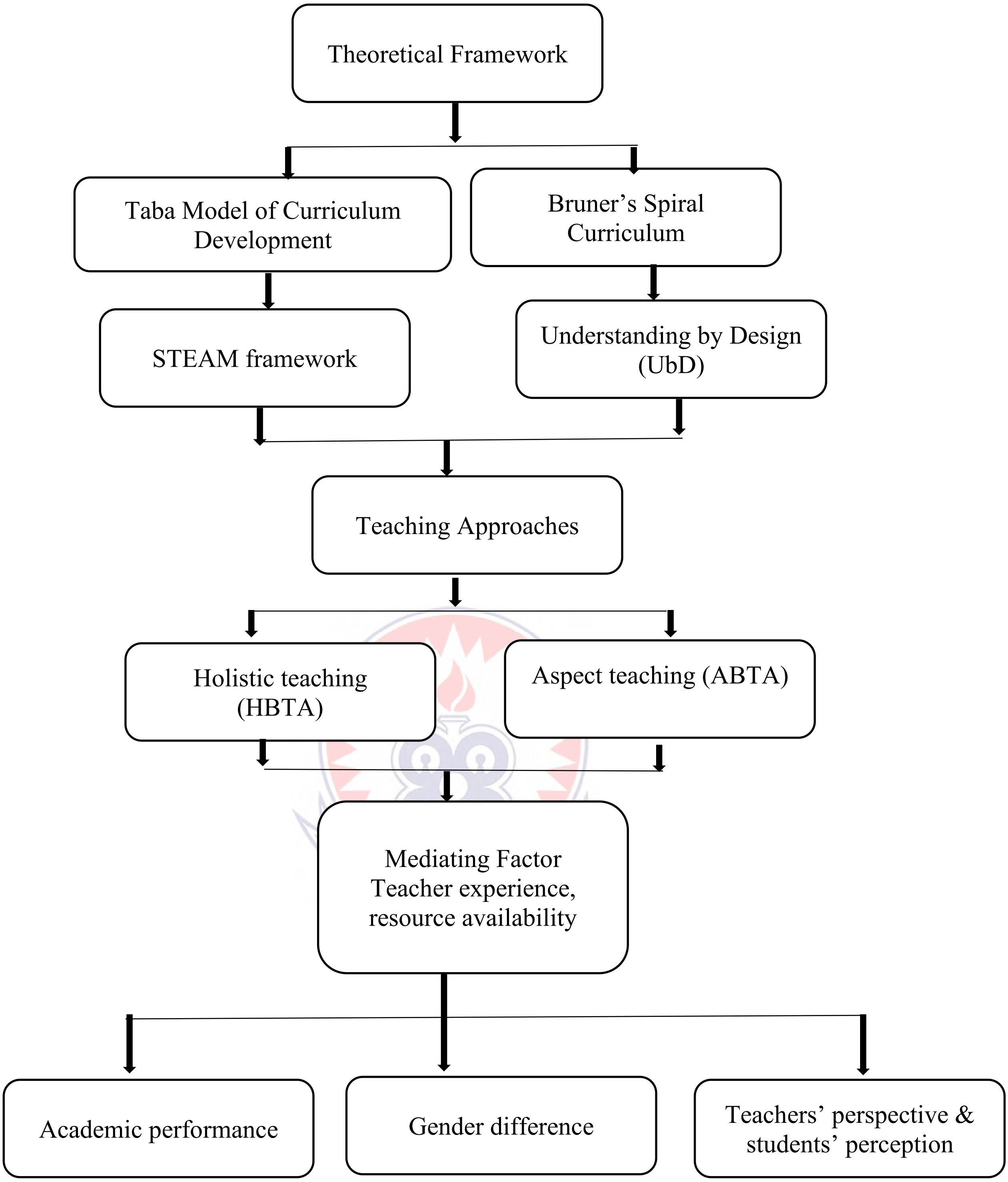

Figure 1: Framework on Effectiveness of Holistic and Aspect Based Teaching (quaye, 2025)

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter outlines the research methodology employed in the study. In the first section of this chapter, the research design is described, highlighting the mixed-methods approach that was adopted. The target population, sampling methods, and the rationale for selecting the participating schools and respondents are also detailed. The chapter explains the research instruments used to collect data, which include interview guides, test scores, and questionnaires. The process of administering these instruments and the steps taken to ensure the reliability and validity of the data are discussed. The chapter also describes the data collection and analysis procedures, Finall, ethical considerations are addressed, ensuring that the rights and well-being of the participants were prioritized throughout the research process.

3.1 Research Design

Research design is a critical component of any study, as it outlines the framework for collecting, analyzing, and interpreting data to address the research objectives effectively. According to Creswell (2018), a well-chosen research design ensures the validity, reliability, and generalizability of findings while aligning with the nature of the research problem. This study employed an evaluative research design coupled with a mixed-methods research approach, a choice justified by the need to assess the effectiveness and perceptions of holistic and aspects-based teaching methods in Integrated Science comprehensively.

The evaluative research design was deemed appropriate for this study because it facilitates the systematic assessment of programs, teaching methods, or interventions to determine their value and impact (Patton, 2015). In this study, the design allows for a detailed evaluation of how both holistic and aspects-based teaching methods influence students' academic performance and perceptions, as well as teachers' experiences with these approaches. This evaluative perspective is essential to providing actionable insights for curriculum developers and policymakers.

The mixed-methods approach was chosen because it combines the strengths of both quantitative and qualitative methodologies, enabling a more robust analysis of the research problem (Tashakkori & Teddlie, 2010). Quantitative methods are employed to measure students' academic performance, and perceptions students regarding these approaches and generate generalizable findings, while qualitative methods are used to explore the perceptions and experiences of teachers. This integration ensures a comprehensive understanding of the research problem by addressing both "what" works (quantitative) and "how" or "why" it works (qualitative).

Moreover, the combined use of these methods aligns with the research objectives, which involve comparing teaching methods, assessing perceptions, and exploring contextual factors influencing teaching and learning. Creswell and Plano Clark (2018) emphasize that mixed methods are particularly valuable in educational research, where diverse stakeholder experiences and measurable outcomes intersect.

3.2 Study Area

The West Akim Municipality, located in the eastern part of the Eastern Region of Ghana. The municipality is one of the 26 administrative districts of the region and plays an important role in the educational landscape of the country. With its combination of urban and rural settlements, West Akim Municipality is representative of the broader socio-economic and educational conditions found in many parts of

Ghana. Geographically, the municipality is bordered by several districts, including the Birim Central Municipality, as well as the Denkyembuor District. The area is characterized by a variety of landscapes, from the densely populated urban centers to the more sparsely populated rural communities.

Educationally, the West Akim Municipality is home to a number of public and private schools, including both junior and senior high schools. The schools in this municipality face various challenges, including large class sizes, limited resources, and variations in the level of infrastructure development across different areas. These challenges make it an interesting setting to explore how teaching methods such as the holistic and aspects-based approaches in Integrated Science might perform under different circumstances. Furthermore, this study can shed light on the specific challenges and opportunities faced by schools in this region, such as the availability of teachers with adequate qualifications, school facilities, and teaching materials.

In particular, the senior high schools selected for this study including Asamankese Senior High School, St. Thomas Senior High and Technical School, and Adieso Senior High School represent a cross-section of schools in the municipality that implement various teaching approaches, including the holistic and aspects-based teaching methods in Integrated Science. Given the municipality's educational and demographic diversity, it serves as a fitting study area for understanding the application and effect of different teaching strategies in science education. The selection of West Akim Municipality for this study offers valuable insights into the educational system in a region that represents both urban and rural educational contexts.

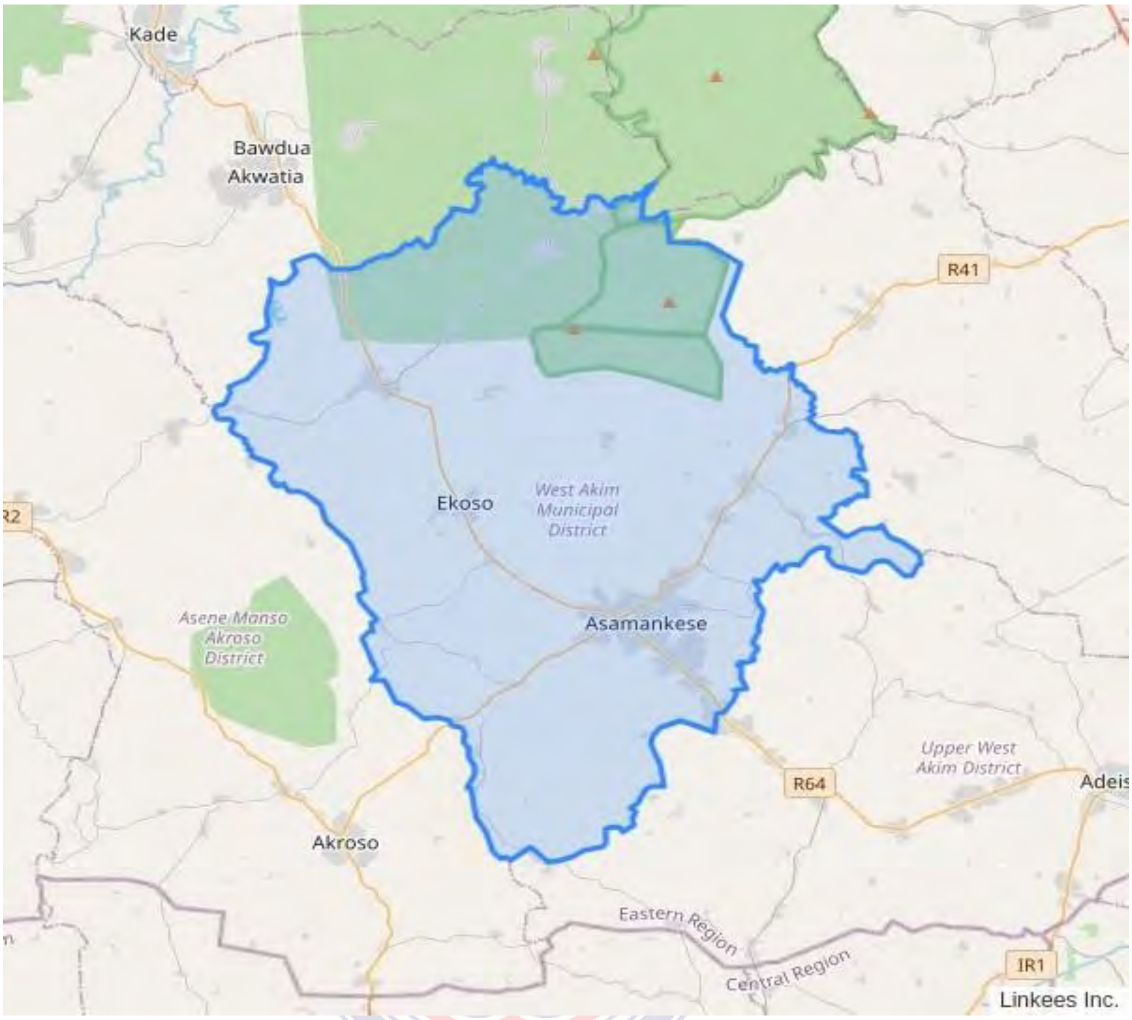

Figure 2: Map of West Akim Municipality

3.3 Research Population

The population of a research study refers to the entire group of individuals or elements from which the researcher seeks to draw conclusions. According to Nworgu (2015), defining the population is critical to ensuring the study's findings are relevant and generalizable to the broader context. For this study, the target population included all students and teachers of Asamankese Senior High School, St. Thomas Senior High and Technical School, and Adeso Senior High School. The accessible population, however, was narrowed to Form 2 General Arts students and Integrated Science teachers from these schools. This delimitation ensures the study is feasible and focused, addressing its specific objectives effectively. The selection of these schools

was intentional, as it aligned with the nature of the study's topic. It was necessary to include schools that exclusively implement the Holistic-Based Teaching Approach (HBTA), the Aspects-Based Teaching Approach (ABTA), and one school that integrates both teaching approaches. This selection strategy allowed for a comparative analysis of the approaches in various educational contexts, ensuring a robust and comprehensive understanding of their effects on students' perceptions and learning outcomes. Specifically, Adeiso Senior High School employed ABTA, St. Thomas Senior High & Technical School (HBTA) and Asamankese Senior High School (BOTH). Additionally, these schools represent different educational settings, offering insights into how the teaching methods are adapted across varied environments.
The choice of Form 2 General Art's students was deliberate, as these students have been exposed to Integrated Science for at least one year, allowing for a more informed evaluation of their perceptions of the teaching methods. Furthermore, Form 2 students are in the middle of their academic journey in senior high school, making them suitable for assessing learning progression without the added pressure of final-year examination preparations. Integrated Science teachers were included because they are the primary implementers of HBTA and ABTA, and their perspectives provide critical insights into the practical application and challenges of these approaches.

In terms of inclusion criteria, the study considered Form 2 General Arts students enrolled in Integrated Science during the academic year, as well as Integrated Science teachers with at least two years of teaching experience in the selected schools. However, the exclusion criteria eliminated students in Forms 1 and 3 to avoid biases associated with the introductory or terminal stages of science education. Teachers who do not teach Integrated Science and those with less than two years of teaching experience were also excluded to ensure that respondents had sufficient exposure to and familiarity with both teaching methods. This targeted sampling strategy ensures the study focuses on participants most likely to provide meaningful data relevant to the research objectives. As Nworgu (2015) highlights, a well-defined population, combined with clear inclusion and exclusion criteria, enhances the validity and reliability of research findings.

3.4 Sample and Sampling Technique

A sample size of 294, which includes 281 students and 13 teachers, is considered appropriate based on the principles of statistical power and the practical limitations of time and resources. According to Creswell (2014), the sample size in educational research should be large enough to allow for the detection of meaningful differences and relationships, while also being feasible in terms of data collection and analysis. A sample size of 281 students provides sufficient power to detect significant differences between groups exposed to the two teaching approaches, particularly when considering the expected variability in academic performance. The inclusion of 13 teachers allows for a diverse understanding of the perspectives and experiences of educators implementing these teaching methods. Using the Slovin's formula, the sample size was determined as;

$n = \frac{N}{1+Ne^2}$, where:

n = Sampling size; e = Margin error (0.05); N = Population size (945)

$n = \frac{945}{1+945(0.05)^2} = 281.04$

Therefore, the sample size for this study was determined to be 281

Table 1: Form 2 General Arts students and Integrated Science Teachers Population Size

Schools	Students	Teachers
Asamankese Senior High School	405	5
St. Thomas Senior High & Technical School	225	4
Adeiso Senior High School	315	4
Total	**945**	**13**

The researcher employed a two-stage sampling technique to select the sample for this study, beginning with stratified random sampling for the selection of students and purposive sampling for the selection of teachers.

In the first stage, stratified random sampling was used to ensure that the sample of students represented the different teaching approaches implemented in the three selected schools. The schools were categorized into three strata: those implementing the HBTA, those employing the ABTA, and those using a combination of both approaches. This stratification allowed for a balanced representation of students exposed to each teaching method, ensuring that the findings would reflect the impact of these approaches on different student groups. After the schools were stratified, simple random sampling was used within each stratum to select the individual students. The researcher used a random technique involving a yes or no paper toss, where students were randomly assigned to the study by tossing a paper with either a "yes" or "no" response. This ensured an unbiased selection process, giving each student an equal chance of being included in the study.

In the second stage, the teachers were selected using purposive sampling. This non-random sampling technique was employed to ensure that the participants had specific characteristics relevant to the study's objectives. Teachers were purposively selected based on their role in teaching Integrated Science, their experience, and their involvement with the teaching approaches under investigation. Specifically, only those teachers who had taught Integrated Science for at least two years and who had experience implementing either the holistic or aspects-based teaching methods were included in the sample. This ensured that the teachers could provide valuable insights into the practical application of these teaching strategies. Purposive sampling, as explained by Patton (2015), is particularly useful when researchers need to select participants who have a deep understanding or direct experience with the phenomenon being studied.

3.5 Research Instruments

The selection of research instruments was crucial to obtaining reliable and valid data. Creswell (2014) emphasized that the instruments employed in research should align with the study's objectives and research questions, ensuring that both qualitative and quantitative data are adequately captured. This study utilized an interview guide, test score, and questionnaires to gather comprehensive information from teachers and students.

3.5.1 Interview guide

An interview guide was employed to explore Integrated Science teachers' perspectives and experiences with holistic and aspects-based teaching methods. The guide, semi-structured in nature, included open-ended questions designed to elicit in-depth responses on teaching strategies, challenges encountered, perceived benefits, and recommendations for improving science education practices. According to Patton (2015), semi-structured interviews allow for a flexible yet focused exploration of participants' experiences, ensuring that critical insights are captured while allowing respondents the freedom to elaborate. Additionally, the interview guide investigated the alignment of these teaching methods with Ghana's competency-based curriculum reforms, providing qualitative data to understand the practical implementation of these approaches in the classroom.

3.5.2 Test score

Test score served as an objective measure of students' academic performance in Integrated Science. Data were collected from students' end-of-term examinations, which were designed to align with the competency-based curriculum. First-semester exam score was used as a baseline, while second-semester exam scores were gathered to further make strong conclusion on students' performance after being taught using either HBTA or ABTA. These quantitative indicators allowed for a comparative analysis of the effectiveness of the two teaching methods. As Mertens (2019) suggested, the use of test score in educational research provide a standardized metric for evaluating learning outcomes and assessing the impact of instructional methods on academic achievement.

3.5.3 Questionnaires

The questionnaires were utilized to capture students' perceptions of the two teaching approaches. Divided into two sections, Section A collected demographic information about the teachers, while Section B assessed students' perceptions of the effectiveness HBTA and ABTA. The questionnaires consisted of closed-ended items, allowing for consistent and quantifiable responses. Bryman (2016) highlighted that closed-ended questionnaires are effective for gathering large-scale perceptual data and ensuring uniformity in responses, facilitating statistical analysis.

3.6 Validity of Research Instruments

In ensuring the accuracy and trustworthiness of the research findings, the researcher employed content and face validity. Content validity was ensured by thoroughly reviewing the research instruments, such as the interview guide, test scores, and questionnaires, to ensure that they aligned with the study's objectives and adequately captured the key constructs. The researcher consulted experts and academic supervisors in the field of science education to ensure that the items in the instruments accurately reflected the relevant content for assessing students' and teachers' perceptions of holistic and aspects-based teaching methods. According to Creswell (2014), content validity is crucial in ensuring that the research instruments cover all the relevant aspects of the constructs being studied, thus enhancing the overall reliability of the data collected.

Face validity was also considered to ensure that the instruments appeared to measure what they were intended to measure. This was done by obtaining feedback from a small sample of teachers and students, who reviewed the questionnaires and interview guide for clarity, relevance, and comprehensiveness. This type of validity focuses on the acceptability and clarity of the research instruments, ensuring that respondents understand the questions and that the instruments accurately capture the intended data. As Mertens (2019) explained, face validity is important in assessing the initial impressions of the research instruments' ability to measure the constructs in question, thus supporting the credibility of the study

3.7 Reliability of Research Instruments

To ensure the consistency and stability of the research instruments, the researcher employed the test-retest method to assess reliability. This approach involved administering the same instruments to a small sample of teachers and students at two different points in time, with an interval of two weeks between administrations. According to Bryman (2016), the test-retest method is widely used in educational research to measure the stability of instruments over time. By comparing the results from the initial and subsequent administrations, the researcher was able to evaluate the consistency of the responses and determine whether the instruments produced reliable and repeatable data.

The test-retest method was specifically applied to the questionnaires and interview guide, as these instruments required consistency in capturing participants' perceptions and experiences with the holistic and aspects-based teaching approaches. For the questionnaires, the researcher examined the correlation between the first and second administrations, expecting a strong positive correlation if the instruments were reliable. Similarly, the interview guide was used consistently in two different rounds of interviews with a small sample of teachers, ensuring that the responses remained stable and reliable over time.

3.8 Data Collection Procedure

The data collection procedure spanned a period of two semesters, during which the researcher followed a systematic approach to gather both qualitative and quantitative data. According to Creswell (2014), a structured and well-planned data collection process ensures that the research objectives are met while maintaining the integrity of the data.

The first step in the data collection process was the administration of the questionnaires to both students and teachers. The questionnaires were distributed to teachers and students in the selected schools, following prior consent and ethical clearance from the institutions. For teachers, the questionnaires were administered to capture their demographic information and their perceptions regarding the use of holistic and aspects-based teaching methods. For students, the second section of the questionnaire focused on assessing their perceptions of the effectiveness of these teaching methods in enhancing their learning experience.

The researcher then conducted interviews with Integrated Science teachers through a Focus Group Discussion (FGD). These discussion were aimed at delving deeper into teachers' experiences and perspectives on implementing the two teaching approaches. The interviews took place in the convenient locations within the school premises to ensure comfort and confidentiality. These interviews were scheduled according to the availability of the participants to minimize disruptions to their teaching schedules. Each interview lasted approximately 30 to 45 minutes, ensuring a detailed exploration of the topic while remaining respectful of participants' time.

In parallel, the researcher gathered test scores from students' end-of-semester exams. The first- semester exam scores were collected as baseline data, and the second-term semester scores were gathered to make a strong conclusion after being taught using either the HBTA or ABTA. This provided a comparative analysis of student performance under the two teaching methods.

All data collection took place within the school academic year, allowing the researcher to capture a representative picture of students' and teachers' experiences with the teaching approaches. The researcher ensured that sufficient time was available to observe and document the impact of the different teaching approaches on both teachers and students.

3.9 Data Analysis Procedure

The data analysis procedure for this study was systematically structured to provide comprehensive insights from the collected data. The analysis spanned both qualitative and quantitative data, ensuring a thorough examination of the research objectives. Firstly, qualitative data from the teacher interviews and focus group discussions (FGDs) were analyzed using thematic analysis. The recorded interviews were transcribed verbatim, and the transcriptions were coded to identify recurring themes and patterns related to teachers' experiences and perspectives on the holistic and aspects-based teaching methods. According to Braun and Clarke (2006), thematic analysis is a flexible and widely used method for identifying, analyzing, and reporting patterns (themes) within qualitative data.Vivo software was utilized to manage and analyze the qualitative data efficiently. This software aided in organizing the data, coding it systematically, and identifying key themes that emerged from the interviews and observations. Thematic analysis provided insights into the benefits, challenges, and perceived effectiveness of each teaching approach.

For the quantitative data, statistical analysis was conducted using SPSS software. Descriptive statistics were calculated to provide an overview of the data, including measures of central tendency (mean) and variability (standard deviation) for students' perceptions and academic performance. These descriptive statistics helped to summarize the data in a meaningful way. Inferential statistics, specifically Analysis of Variance (ANOVA), were employed to compare the academic performance of students taught using the holistic approach versus those taught using the aspects-based approach. The ANOVA test was chosen to determine whether there were significant differences in academic outcomes between the two groups. According to Field (2013), ANOVA is an appropriate statistical technique when comparing the means of more than two groups, helping to assess the impact of different teaching approaches on student performance.

The analysis focused on examining whether students exposed to holistic teaching approaches demonstrated higher engagement and conceptual understanding of Integrated Science than those exposed to aspects-based teaching approaches. Data were presented in tables and visuals to facilitate a clear understanding of the findings. These visualizations helped in illustrating the differences in students' academic performance, as well as their perceptions of the effectiveness of each teaching method.

3.10 Ethical Considerations

The researcher ensured informed consent, confidentiality, and participant well-being. All participants, including teachers and students, were fully informed about the study's purpose, procedures, and their rights, including the right to withdraw from the study at any time without consequence. Personal data were anonymized and securely stored, teachers were coded as A001 - A013 to ensure anonymity, and their responses were reported in an aggregated form, ensuring that individual identities were not disclosed in the findings. This approach was taken to protect the privacy of participants while maintaining the validity and integrity of the data collected. The study design was non-invasive, minimizing disruption and discomfort for participants during data collection. Ethical approval was obtained from the relevant ethics committee and the authorities of the various schools used for the study, and debriefing sessions were conducted with participants to maintain transparency and trust throughout the study.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Overview

This chapter presents the findings of the study based on the analysis of data collected regarding the implementation of holistic-based teaching (HBTA) and aspect-based teaching (ABTA) in Integrated Science. The analysis focused on the students' academic performance, effectiveness of both teaching approaches, challenges faced by teachers, and student' perception about the learning approaches. The results are discussed in relation to the research objectives.

4.1 Demographic Information of Teachers

Table 2 illustrates the demographic information of 13 Integrated Science teachers, revealing their characteristics and teaching experiences. Gender distribution shows that male teachers constituted 61.54%, while female teachers accounted for 38.46%, indicating a slightly higher representation of males. Age distribution reveals that 38.46% of the teachers were aged between 31–40 years, followed by 30.77% in the 41–50 years category. Teachers aged 20–30 years and 51 years and above each accounted for 15.38%, showcasing diversity in age groups. Teaching experience varied, with 30.77% having 5–10 years or 11–15 years of experience, respectively. Teachers with less than 5 years of experience made up 23.08%, while those with more than 15 years constituted 15.38%. Educational qualifications indicated that the majority, 46.15%, held a Bachelor's Degree in Integrated Science Education. This was followed by 23.08% holding a Master's Degree in Science Education and 23.08% with a Post Graduate Diploma, while 7.69% had other qualifications.

Formal training in Holistic-Based Teaching Approach (HBTA) or Aspects-Based Teaching Approach (ABTA) was reported by 38.46% of the teachers, while 61.54% had not received such training. Teaching preferences show that 53.85% of the teachers favored HBTA and 38.46% favored ABTA, while 7.69% expressed no preference.

Table 2: Teachers' Demographic Information

Characteristic	Frequency	Percent (%)
Gender		
Male	8	61.54
Female	5	38.46
Age Group		
20 – 30 years	2	15.38
31 – 40 years	5	38.46
41 – 50 years	4	30.77
51 years and above	2	15.38
Years Teaching Integrated Science		
Less than 5 years	3	23.08
5 – 10 years	4	30.77
11 – 15 years	4	30.77
More than 15 years	2	15.38
Highest Level of Education		
Post Graduate Diploma	3	23.08
Bachelor's Degree in Integrated Science Education	6	46.15
Master's Degree in Science Education	3	23.08
Other	1	7.69
Formal Training in HBTA/ABTA		
Yes	5	38.46
No	8	61.54
Teaching Preference for Integrated Science		
Holistic-Based Teaching Approach (HBTA)	7	53.85
Aspects-Based Teaching Approach (ABTA)	5	38.46
No Preference	1	7.69

4.2 Research Question One: What is the comparative effect of holistic and aspects-based teaching on students' academic performance in Integrated Science?

This section examined the comparative effect of HBTA and ABTA on students' academic performance in Integrated Science. The analysis focused on how each approach influenced student learning, comprehension, and overall achievement. Findings were presented based on students' semester exam scores, highlighting differences in performance across the two teaching methods.

Out of the total sample size of 281 students, the academic records of 171 students, 57 from each school were successfully obtained for data analysis, representing 60.9% of the sample. The achievement of this percentage aligns with studies that highlight the significance of adequate sample representation in educational research. According to Creswell (2014), a response rate of 60% or higher is generally considered acceptable for quantitative studies, ensuring that the collected data is sufficient for meaningful analysis. Similarly, Fowler (2013) suggests that achieving a sample retention rate above 50% enhances the reliability and generalizability of research findings. In this study, the 60.9% data retention provides a reasonable basis for examining the comparative effects of holistic-based teaching (HBTA) and aspect-based teaching (ABTA) on students' academic performance in Integrated Science.

Table 3: Exams Scores of Students on ABTA and HBTA in Semester One

Marks Range	Adeiso SHS (Aspect)	St. Thomas SHTS (Holistic)	Asamankese SHS (Both)
60–65	7	8	6
66–70	6	6	7
71–75	8	7	6
76–80	10	9	8
81–85	15	12	14
86–90	8	7	10
91–95	3	1	2
Total (N)	**57**	**57**	**57**
Mean ± SD	**74.54 ± 12.32**	**74.47 ± 12.78**	**76.82 ± 11.63**

Table 3 presents the first-semester performance of students across the three senior high schools, each employing a different teaching approach: the aspects-based teaching approach (ABTA) at Adeiso Senior High School, the holistic-based teaching approach (HBTA) at St. Thomas Senior High & Technical School, and a combination of both approaches at Asamankese Senior High School. The results reveal notable insights into the effectiveness of each teaching method. The mean performance of students taught using ABTA at Adeiso Senior High School was 74.54 ± 12.32, while those using HBTA at St. Thomas Senior High & Technical School recorded a mean of 74.47 ± 12.78. These figures suggest that, on average, both teaching approaches yielded nearly identical student performance, indicating that neither method demonstrated a significant advantage over the other in the first semester. However, students at Asamankese Senior High School, who were exposed to a combination of both ABTA and HBTA, achieved a slightly higher mean of 76.82 ± 11.63 in the second semester. This suggests that integrating both teaching methods may have contributed to a more effective learning process, potentially enhancing students' comprehension and retention of Integrated Science concepts.

While both ABTA and HBTA resulted in similar performance levels, individual student scores reveal variations. Some students in the holistic-based approach performed significantly lower than those in the aspect-based approachThe slightly higher mean performance of students exposed to both approaches suggests that integrating holistic and aspect-based teaching methods could provide a more balanced learning experience, fostering both conceptual understanding and subject mastery.

Table 4: Exams Scores of Students on ABTA and HBTA in Semester Two

Marks Range	Adeiso SHS (Aspect)	St. Thomas SHTS (Holistic)	Asamankese SHS (Both)
55–60	2	4	2
61–65	3	3	4
66–70	4	2	5
71–75	6	5	7
76–80	10	7	9
81–85	18	17	15
86–90	12	17	13
91–95	2	2	2
Total (N)	**57**	**57**	**57**
Mean ± SD	**78.40 ± 10.09**	**83.23 ± 10.00**	**77.72 ± 11.58**

In the second semester, as shown in Table 4, student performance varied based on the teaching approach used in each school. St. Thomas Senior High & Technical School, which implemented the holistic-based teaching approach (HBTA), recorded the highest mean score of 83.23 ± 10.00, showing a significant improvement from its first-semester mean of 74.47 ± 12.78. This suggests that as students became more accustomed to HBTA, they may have developed a stronger ability to integrate scientific concepts across disciplines, leading to better overall academic performance. The relatively lower standard deviation (10.00) also indicates a more consistent performance among students.

Adeiso Senior High School, which used the aspects-based teaching approach (ABTA), recorded a mean score of 78.40 ± 10.09, which, although improved from the first semester (74.54 ± 12.32), remained lower than that of the holistic-based approach. This suggests that while ABTA may have helped students focus more on individual science subjects, its impact on overall academic performance was not as strong as HBTA. The standard deviation (10.09) was comparable to that of HBTA, indicating a similar level of performance variability among students.

Asamankese Senior High School, which combined both HBTA and ABTA, had the lowest mean score of 77.72 ± 11.58, showing only a slight change from its first-semester mean of 76.82 ± 11.63. The higher standard deviation (11.58) suggests that student performance was more varied in this group, indicating that while some students benefited from the combined approach, others may have struggled to adapt to both teaching methods. This could imply that while integrating both approaches offers a balanced learning experience, it may require additional instructional strategies to ensure that all students benefit equally.

A closer examination of individual scores further highlights important trends. Some students in the HBTA group excelled, with scores reaching as high as 91, reinforcing the idea that a holistic approach may promote higher-order thinking and knowledge integration. However, the lowest-performing students in this group still scored as low as 61, indicating that some students may struggle with the interconnected nature of HBTA. In contrast, the ABTA group had a more evenly distributed performance, but with a slightly lower upper range of scores. Meanwhile, the combined approach group exhibited significant variability, with some students performing exceptionally well while others struggled, further emphasizing the need for tailored instructional support in mixed-teaching environments.

Hypothesis

Testing Null hypothesis (H_{01}): There is no significant difference in students' academic performance in Integrated Science between the holistic teaching approach and the aspect-based teaching approach.

Alternative Hypothesis (H_1): Holistic teaching approaches significantly improve students' academic performance in Integrated Science compared to aspect-based teaching approaches.

The analysis aimed to test the hypothesis that holistic teaching approaches significantly improve students' academic performance in Integrated Science compared to aspect-based teaching approaches. The results from the one-way ANOVA presented in

Table 5: One-Way ANOVA with Tukey's Post-Hoc Comparison of Teaching Approaches

Source	Sum of Squares	Df	Mean Square	F	p-value	η^2	Significance
Teaching Approach	220.23	2	110.12	0.91	0.4031	.005	Ns
Error	40583.19	336	120.79				
Total	40793.42	338					

p<0.05, p<0.01, p<0.001, ns: not significant

The results in Table 5 shows that there is no significant difference in exam scores between the three teaching approaches (ABTA, HBTA, and Both). The one-way ANOVA gave an F-value of 0.91 with a p-value of 0.403, which is much higher than 0.05, meaning the differences in average scores are not statistically meaningful.

Table 6: Tukey's HSD Post-Hoc Results

Comparison	Mean Difference	p-value	Significance
ABTA vs HBTA	-0.07	0.98	Ns
ABTA vs Both	-2.28	0.41	Ns
HBTA vs Both	-2.21	0.43	Ns

p<0.05, p<0.01, p<0.001, ns: not significant

Tukey's post-hoc test in Table 6 confirmed this by showing that none of the pairwise comparisons (ABTA vs HBTA, ABTA vs Both, HBTA vs Both) were significant. In simple terms, students performed at similar levels regardless of whether they were taught using the aspect-based approach, the holistic approach, or a combination of both. The effect size was very small ($\eta^2 = .005$), which means the teaching approach explained almost none of the variation in students' scores. This suggests that other factors, such as teacher expertise, resources, or student background, may have had a stronger influence on performance than the teaching method itself. This finding suggests that the effectiveness of a teaching approach varied depending on the semester, implying that the impact of holistic and aspect-based teaching methods on student performance may change over time.

Table 7: Post-hoc Analysis Results

Group 1	Group 2	Mean Diff	Lower	Upper	p-value	Sig.
Semester 1_HOLISTIC	Semester 2_HOLISTIC	-8.76	-13.26	-4.26	0.0001	***
Semester 1_ASPECT	Semester 2_HOLISTIC	-8.69	-13.19	-4.19	0.0001	***
Semester 1_HOLISTIC	Semester 2_ASPECT	-3.93	-8.43	0.57	0.1291	ns
Semester 1_BOTH	Semester 2_HOLISTIC	-6.41	-10.91	-1.92	0.0010	
Semester 2_HOLISTIC	Semester 2_BOTH	5.51	1.01	10.01	0.0062	

p<0.05, p<0.01, p<0.001, ns: not significant

The post-hoc analysis in Table 7 provides further insights into this interaction effect. The results showed that students in the holistic-based teaching group experienced significant improvement from semester 1 to semester 2 (mean difference = -8.76, $p = 0.0001$), indicating that consistent exposure to holistic teaching over time enhanced performance. Similarly, students in the aspect-based teaching group also showed significant improvement between semesters (mean difference = -8.69, $p = 0.0001$), further confirming that both methods can contribute to academic progress when applied over an extended period.

However, the comparison between semester 1 holistic and semester 2 aspect-based teaching was not statistically significant ($p = 0.1291$), which reinforces the earlier ANOVA result that no single teaching method was superior. Interestingly, students in the holistic-based approach during the second semester performed significantly better than those who experienced a combination of both methods (mean difference = 5.51, $p = 0.0062$), suggesting that maintaining a consistent holistic teaching approach may yield better academic outcomes than blending the two strategies.

Therefore, the findings do not fully support the hypothesis that holistic teaching significantly improves students' academic performance in Integrated Science compared to aspect-based teaching. Both approaches led to improvements in student performance over time, but neither approach proved superior. The significant interaction effect highlights that the effectiveness of a teaching approach depends on the duration and consistency of its application, rather than the approach itself being inherently more effective.

4.3 Research question Two: what differences exist in the academic performance of male and female students taught when using holistic and aspect-based teaching methods in Integrated Science?

This section examined whether there was a difference between male and female students in their academic performance when taught using holistic-based teaching (HBTA) and aspect-based teaching (ABTA) in Integrated Science. The analysis focused on variations in student achievement based on gender. Findings were presented based on students' semester exam scores, highlighting any differences in performance between male and female students under the two teaching methods.

Table 8: Comparing female and male SHS students' academic performance in Aspect - Based Teaching Approach (ABTA) (both semesters)

Marks Range	Girls (Frequency)	Boys (Frequency)
120–129	2	0
130–139	3	2
140–149	4	4
150–159	7	6
160–169	10	12
170–179	6	6
Total (N)	**32**	**24**
Mean ± SD	**154.85 ± 14.35**	**152.13 ± 10.79**

The analysis of the academic performance (combined semesters) of male and female students at Adeso Senior High School under the aspect-based teaching approach (ABTA), as shown in Table 8, reveals that there is minimal difference between the two groups. The data reflects combined results from two semesters (semester 1 and 2), providing a more comprehensive measure of academic achievement across the academic year. Female students achieved an average score of 154.85 with a standard deviation of 14.35, while male students recorded a mean score of 152.13 with a standard deviation of 10.79. The slightly higher mean score for girls indicates marginally better performance; however, the difference of 2.72 points is relatively small, suggesting that both genders performed similarly. The higher standard deviation for girls reflects greater variability in their scores, with some performing exceptionally well while others scored lower. In contrast, the boys' performance was more consistent, as shown by their lower standard deviation. The maximum score for girls was 179, while for boys, it was 174, and the minimum scores were 122 and 133, respectively. This indicates that the girls' performance spanned a wider range compared to that of the boys. The small gap in mean scores and the overlap in performance ranges suggest that gender does not significantly influence academic performance under the aspect-based teaching approach. The results imply that factors other than gender, such as individual learning strategies or classroom dynamics, may have contributed to the observed differences.

Table 9: Comparing female and male SHS students' academic performance in HBTA (both semesters)

Marks Range	Girls (Frequency)	Boys (Frequency)
120–129	0	0
130–139	2	3
140–149	4	5
150–159	10	7
160–169	11	7
170–179	4	3
Total (N)	**31**	**25**
Mean ± SD	**156.06 ± 10.63**	**151.23 ± 13.07**

On the other hand, the academic performance of male and female students at St. Thomas Senior High & Technical School, as shown in Table 9, reflects a minor variation under the holistic-based teaching approach. Female students attained a mean score of 156.06 with a standard deviation of 10.63, while their male counterparts achieved an average score of 151.23 with a standard deviation of 13.07. Although the girls outperformed the boys by 4.83 points, the margin is relatively small, indicating that the difference in performance is not significant. The lower standard deviation for girls signifies more consistent performance, while the higher standard deviation for boys shows greater fluctuation in their scores. The highest score for girls was 175, whereas for boys, it was 172. The lowest scores were 136 and 130 for girls and boys, respectively, suggesting that boys' performance varied slightly more than that of the girls. These findings imply that gender has little influence on academic performance when the holistic-based teaching approach is applied. The results suggest that factors such as teaching strategies and students' individual efforts might have contributed to the observed differences.

Hypothesis

Testing Null Hypothesis (H_{02}): *There is no significant difference between male and female students in their academic performance when taught using holistic and aspect-based teaching methods in Integrated Science.*

Alternative Hypothesis (H_2): There is a significant difference between male and female students in their academic performance when taught using holistic and aspect-based teaching methods in Integrated Science.

Table 10: Descriptive Statistics (Aspect)

Gender	Count	Mean	Std Dev	Min	Max
Girls	33	154.85	14.01	122	179
Boys	24	153.08	10.79	133	174

Table 11: Summary of ANOVA Results

Source of Variation	Df	Sum of squares	Mean Square	F	p-value
Between Groups	1	48.29	48.29	0.30	0.5845
Within Groups	55	8808.09	160.15		
Total	56	8856.38			

The results from both the descriptive statistics (Table 10) and ANOVA (Table 11) indicate that gender differences in performance are not statistically significant, implying that male and female students respond similarly to these teaching methods. The ANOVA results in Table 10 (F = 0.30, p = 0.5845) show that the difference between the two groups was not statistically significant. This high p-value suggests that the observed difference is likely due to chance and not an actual academic advantage associated with gender. Therefore, under the aspect-based teaching approach (ABTA), both male and female students performed consistently, with no evidence of one gender outperforming the other.

Table 12: Descriptive Statistics (Holistic)

Gender	Count	Mean	Std Dev	Min	Max
Girls	31	156.06	10.63	136	175
Boys	26	151.23	13.07	130	172

Table 13: Summary of ANOVA Results

Source of Variation	Df	Sum of squares	Mean Square	F	p-value
Between Groups	1	367.16	367.16	2.63	0.1107
Within Groups	55	7675.77	139.56		
Total	56	8042.93			

However, the ANOVA results in Table 13 (F = 2.63, p = 0.1107) indicate that this difference was not statistically significant. This implies that the difference in performance between male and female students under the holistic-based teaching approach (HBTA) is not substantial enough to support the alternative hypothesis

Table 14: Summary of All Gender-Teaching Method Comparisons

Comparisons	Group 1	Group 2	Mean difference	F	p-value	Significance
Girls (ASPECT) vs Boys (HOLISTIC)	154.85	151.23	3.62	1.03	0.3149	No
Girls (HOLISTIC) vs Boys (ASPECT)	156.06	157.83	-1.77	0.39	0.5356	No
Boys (ASPECT) vs Boys (HOLISTIC)	157.83	151.23	6.60	3.01	0.0892	No
Girls (ASPECT) vs Girls (HOLISTIC)	154.85	156.06	-1.21	0.14	0.7055	No

The post-hoc analysis further confirms this conclusion in Table 14. The comparison between girls (ABTA) and boys (HBTA) revealed a mean difference of 3.62 with a p-value of 0.3149, which is not statistically significant. Likewise, the comparison between girls (HBTA) and boys (ABTA) showed a mean difference of -1.77 with a p-value of 0.5356, also not significant. The comparison between boys (ABTA) and boys (HBTA) revealed a mean difference of 6.60 with a p-value of 0.0892, which is relatively closer to significance but still exceeds the 0.05 threshold. Lastly, the comparison between girls (ABTA) and girls (HBTA) yielded a mean difference of -1.21 with a p-value of 0.7055, further confirming the absence of significant gender differences in performance across the teaching methods. In conclusion, the findings suggest that neither the aspect-based teaching approach (ABTA) nor the holistic-based teaching approach (HBTA) favors one gender over the other. The lack of significant differences in performance between male and female students indicates that both genders have equal potential to excel in Integrated Science when exposed to these teaching strategies. Therefore, the null hypothesis, which states that there is no significant difference between male and female students' academic performance when taught using holistic and aspect-based teaching methods, is accepted, while the alternative hypothesis is rejected.

4.4 Research Question Three: What are teachers' perspectives and experiences with implementing holistic and aspects-based teaching of Integrated Science in senior high school?

This section examined teachers' perspectives and experiences with implementing HBTA and ABTA in Integrated Science at the senior high school level. The analysis focused on how teachers applied these methods, the challenges they faced, and their observations on student engagement and learning outcomes. Findings were presented based on qualitative responses from teachers, highlighting their practical experiences with both approaches.

4.4.1 Teaching Strategies and Approach

The responses from teachers revealed diverse approaches to implementing holistic-based teaching (HBTA) and aspect-based teaching (ABTA) in Integrated Science classes. While some school adhered strictly to one method, others combined both strategies. The choice of approach was largely influenced by factors such as curriculum requirements, examination structure, and students' comprehension levels.

Teachers who primarily used the aspect-based approach (ABTA) emphasized its structured nature, which allows students to focus on one scientific discipline at a time. They explained that this method ensures that concepts are broken down into manageable sections, reducing cognitive overload for students. A005 stated,

> *"I usually teach Physics, Chemistry, Biology and Agricture separately so that students can fully understand each concept before integrating them."*

Similarly, A009 highlighted the advantage of ABTA in preparing students for assessments, saying,

> *"Breaking topics into their respective disciplines helps students focus on the specifics, which is useful when answering exam questions."*

Another teacher, A002, noted that the aspect-based approach is particularly helpful for students who struggle with interdisciplinary learning, stating,

> *"Some students get confused when concepts are taught together, so I prefer to keep them separate to ensure clarity."*

On the other hand, teachers who adopted the holistic-based approach (HBTA) explained that it fosters critical thinking and allows students to see the connections between different scientific fields. This approach was particularly favored for topics that require interdisciplinary understanding. A003 explained,

> *"I introduce a real-world problem and allow students to explore the biological, chemical, and physical aspects of the issue together. This way, they see how science is interconnected."*

A011 also stressed the practical application of HBTA, stating,

> *"I use case studies, such as examining the water cycle and its role in weather patterns, alongside project-based learning. For example, students create models to simulate evaporation, condensation, and precipitation. This allows them to understand how physics, chemistry, and biology come together to explain natural phenomena, such as rainfall and climate systems."*

In engaging students effectively, teachers reported using a variety of strategies such as practical demonstrations, group discussions, inquiry-based learning, and problem-solving tasks. Those who implemented HBTA frequently used case studies and real-life scenarios, while ABTA-focused teachers relied on structured lesson plans and sequential instruction. Some teachers also highlighted the importance of adapting their teaching methods to students' abilities and interests to ensure better engagement.

4.4.2 Challenges in Implementation

The teachers highlighted several challenges in implementing both the holistic-based teaching approach (HBTA) and the aspect-based teaching approach (ABTA) in their Integrated Science classrooms. While some difficulties were unique to each method, others were common across both approaches. These challenges affected lesson delivery, student comprehension, and overall engagement. One of the most common issues reported with the holistic-based approach was the complexity of integrating multiple scientific disciplines into a single lesson. A004 explained,

> *"It can be overwhelming for students to process concepts from different branches of science at once. Some of them struggle to make connections between topics, which affects their understanding."*

A012 also pointed out the challenge of time constraints, stating,

> *"Teaching holistically requires more time to fully explore interdisciplinary connections, but the curriculum is packed, and we often have to rush through topics."*

Some teachers also mentioned the difficulty in finding appropriate teaching materials that effectively integrate concepts across different scientific fields. For the aspect-based approach, teachers identified the issue of students struggling to relate scientific concepts across disciplines. A006 noted,

> *"Since topics are taught separately, some students fail to see how physics, chemistry, biology and agric are interconnected. This makes it harder for them to apply knowledge to real-world problems."*

A009 also expressed concerns about student engagement, saying,

> *"Some students find aspect-based teaching too rigid and repetitive. They memorize concepts for exams but struggle to apply them in practical situations."*

In terms of addressing these challenges, teachers employed various strategies. Those who faced difficulties with holistic teaching adjusted their approach by gradually integrating concepts rather than presenting everything at once. A011 shared,

> *"I introduce the scientific disciplines separately at the beginning of a topic and then combine them in practical activities so that students can see the connections at their own pace."*

Teachers using aspect-based teaching, on the other hand, introduced real-world applications to help students relate different scientific concepts. A002 explained,

> *"I use case studies and cross-disciplinary discussions to bridge the gap between subjects. This helps students understand how different scientific principles work together."*

Despite these challenges, teachers emphasized that both approaches have their benefits when properly structured. Some teachers preferred alternating between the two methods depending on the requisite knowledge and mastery of content.

4.4.3 Perceived Effectiveness and Student Engagement

The findings showed that teachers had diverse perspectives on the effectiveness of holistic-based teaching (HBTA) and aspect-based teaching (ABTA) in engaging students and improving their academic performance in Integrated Science. While some teachers observed that students responded better to one approach over the other, others noted that the effectiveness depended on the topic, student background, and teaching style. Many teachers emphasized that student engagement, interest, and academic performance varied depending on how the approach was implemented, the resources available, and the nature of the students being taught.

Several teachers highlighted that holistic teaching enhances critical thinking and real-world application of scientific concepts, making lessons more engaging for students.

A007 stated,

> *"When I use the holistic approach, students participate more actively because they can relate concepts to everyday life. It helps them understand the bigger picture rather than just memorizing isolated facts."*

A011 pointed out that HBTA encourages deeper discussions, saying,

> *"Students tend to ask more questions and think critically about how different scientific principles are connected."*

Another teacher, A004, explained that students generally find holistic teaching more interesting when learning about ecosystem and energy, stating,

> *"When discussing ecosystem, I use a holistic approach to show the biological, chemical, and physical aspects of the topic. This makes students more curious and involved in the lesson."*

However, some teachers noted that weaker students sometimes struggle with holistic teaching. A005 explained,

> *"While high-performing students enjoy making connections across disciplines, some students find it overwhelming and prefer a more structured approach."*

A013 similarly mentioned that some students lose focus when too many concepts are introduced at once, making it difficult for them to retain information.

On the other hand, the aspect-based teaching approach was seen as more effective for building foundational knowledge and helping students retain subject-specific details. A003 shared,

> *"ABTA helps students focus on specific subjects, which makes it easier for them to grasp difficult concepts before applying them."*

A010 observed that,

> *"Students tend to perform better in structured assessments when taught using aspect-based teaching because it aligns with how class test questions are usually framed."*

Many teachers agreed that this approach provides a step-by-step learning process that reduces confusion and makes it easier for students to recall concepts. However, some teachers noted that ABTA can make science seem fragmented, limiting students' ability to see the relationships between different scientific principles.

A013 mentioned,

> *"Some students struggle to see the relationship between scientific concepts when they are taught separately, which can limit their ability to apply knowledge in practical situations."*

A002 added that,

> *"In real-world science applications, knowledge is integrated, so a purely aspect-based approach sometimes makes it harder for students to think critically beyond their subject areas."*

When it comes to student engagement, teachers reported mixed reactions. Some students preferred the structured nature of aspect-based teaching, while others were more engaged in the interactive discussions and problem-solving activities encouraged by holistic teaching.

A002 shared,

> *"For practical experiments, students respond better to the holistic approach because they can see how different disciplines come together. But for theoretical topics, they sometimes prefer aspect-based teaching since it breaks down information into simpler parts."*

A006 observed that,

> *"Students who are good at memorization and structured learning tend to excel in aspect-based teaching, while those who enjoy interactive learning prefer the holistic approach."*

Another key observation was that the effectiveness of each approach depended on student background and learning style. Some teachers noted that students from rural areas or with limited prior science knowledge tended to benefit more from the structured approach of ABTA, while those with stronger foundational knowledge were able to engage more deeply with HBTA. A009 explained,

> *"Students who struggle with science need a structured approach first before they can apply concepts holistically."*

Meanwhile, A012 pointed out that,

> *"High-achieving students are more likely to enjoy the holistic approach because it challenges them to think beyond isolated topics."*

Many teachers agreed that using a flexible teaching approach that adapts to student needs is the best way to enhance learning outcomes in Integrated Science.

4.4.4 Resource Availability and Institutional Support

Teachers highlighted the significant role that resources and institutional support play in the effective implementation of holistic-based teaching (HBTA) and aspect-based teaching (ABTA) in Integrated Science. Many teachers agreed that the availability or lack of essential teaching materials, such as laboratory equipment, textbooks, and technology, greatly impacts how they deliver lessons and engage students in practical learning experiences. Several teachers noted that limited access to laboratory equipment was one of the biggest challenges in implementing both HBTA and ABTA. A006 emphasized that inadequate resources hinder student engagement, stating,

> *"Science teaching requires practical demonstrations, but with inadequate lab equipment, students struggle to connect theoretical concepts to real-life applications."*

A002 further explained that this issue is especially problematic for aspect-based teaching, saying,

> *"For aspect-based teaching, well-equipped labs help students conduct experiments specific to physics, chemistry, or biology and agric. Without these, teaching becomes mostly theoretical, which affects student understanding."*

Teachers implementing HBTA also faced similar challenges, as integrating multiple scientific concepts often requires interdisciplinary experiments. A007 highlighted this difficulty, explaining,

> *"Holistic teaching is difficult when we don't have enough resources to conduct experiments that link different scientific disciplines. Many times, we rely on explanations rather than practical activities."*

Apart from laboratory resources, the availability of textbooks and teaching guides was another concern. A011 pointed out that most textbooks follow an aspect-based structure, making it difficult to teach holistically, stating,

> *"Most textbooks separate physics, chemistry, biology and agric topics, which makes it harder to implement holistic teaching. I have to gather information from each aspect to create a lesson that integrates all aspects."*

A004 also noted that outdated learning materials further compound this issue, adding,

> *"Some schools lack updated textbooks, so students rely mostly on class notes, which limits their exposure to broader scientific knowledge."*

Teachers also highlighted the role of technology in improving the teaching and learning process. Many agreed that access to digital resources, such as interactive simulations and online science platforms, would enhance both HBTA and ABTA.

A010 emphasized the importance of technology in making abstract concepts easier to understand, explaining,

> *"Technology can make abstract concepts easier to understand, especially in a holistic approach where students need to see how scientific principles interact. However, not all schools have projectors, computers, or internet access."*

A012 added that virtual lab simulations could be a useful alternative to physical resources, stating,

> *"If we had more access to virtual lab simulations, students could conduct experiments even when physical equipment is unavailable."*

Regarding institutional support, teachers suggested several ways schools and educational authorities could enhance the effectiveness of these teaching approaches. A009 stressed the need for increased funding, stating,

> *"If schools receive more funding, we can stock our labs with essential materials and ensure every student gets hands-on experience."*
>
> Another key recommendation was teacher training and workshops to help educators better integrate both approaches. A003 pointed out the need for professional development, explaining,
>
> *"Workshops on how to balance holistic and aspect-based teaching would be helpful. Many teachers rely on one approach because they are more comfortable with it."*

Additionally, some teachers called for a curriculum revision to align teaching materials with practical applications. A005 noted that the current curriculum is heavily exam-focused, stating,

> *"The curriculum should be structured in a way that encourages practical learning rather than just theoretical knowledge. Right now, we are limited by the examination-focused nature of the system."*

Others highlighted the importance of school leadership support, with A013 stating,

> *"Administrators should ensure that science departments receive the necessary resources and that teachers are not left to struggle on their own."*

Teachers believed that addressing these challenges would lead to better student engagement, deeper understanding, and improved academic performance in Integrated Science.

4.4.5 Recommendations for Improvement

The teachers highlighted several recommendations and policy changes that could enhance the effectiveness of teaching Integrated Science using holistic-based teaching (HBTA) and aspect-based teaching (ABTA). Many teachers emphasized the need for improvements in curriculum design, resource allocation, professional development, and institutional support to ensure that both teaching approaches can be effectively implemented. A009 stressed the importance of curriculum restructuring, stating,

> *"The curriculum should be designed in a way that allows for a balance between holistic and aspect-based teaching. Right now, the focus is mostly on segmented learning, making it difficult to integrate concepts."*

Some teachers pointed out that current educational policies emphasize preparing students for standardized examinations, which favors the aspect-based approach. A002 explained,

> *"There should be a shift from exam-centered learning to an approach that promotes deep understanding. If holistic teaching is encouraged, students will develop better analytical and problem-solving skills."*

A007 suggested that a review of assessment methods would also help, stating,

> *"Exams should not only test memorization of concepts but also assess students' ability to apply knowledge from different scientific disciplines."*

Teachers also identified resource allocation as a key area for improvement. Many noted that the availability of laboratory equipment, textbooks, and digital learning tools plays an important role in determining the effectiveness of these teaching methods. A013 emphasized the need for well-equipped science laboratories, explaining,

> *"Without the necessary lab equipment, it becomes difficult to implement practical aspects of holistic and aspect-based teaching. Schools need consistent funding to ensure that students have access to the materials they need."*

A011 added that textbook revision should be prioritized, stating,

> *"Most science textbooks focus on isolated disciplines, making it difficult to apply a holistic approach. There should be Integrated Science textbooks that help students connect concepts across different fields."*

Another major recommendation was training and professional development for teachers. A003 stressed the need for workshops and refresher courses, stating,

> *"Many teachers rely on one approach simply because they were not trained to effectively use both. Regular professional development programs should be introduced to help teachers adopt both methods effectively."*

A006 suggested that training should include hands-on strategies, explaining,

> *"Workshops should not just focus on theoretical discussions but should provide practical demonstrations of how holistic and aspect-based teaching can be applied in the classroom."*

Some teachers also recommended peer-learning programs, where educators can share best practices. A012 stated,

> *"Learning from colleagues who have successfully implemented both approaches would be beneficial. Schools should organize professional learning communities for science teachers."*

Institutional support was also identified as a crucial factor in improving teaching effectiveness. A005 highlighted the need for strong leadership and administrative backing, explaining,

> *"School administrators should take an active role in supporting science education by ensuring that teachers have the necessary resources and training."*

A010 suggested that government policies should prioritize science education, stating,

> *"If science education is taken more seriously at the policy level, there will be better investment in training programs, infrastructure, and teaching materials."*

4.5 Research Question Four: What are students' perceptions of the use of holistic and aspects-based teaching in Integrated Science?

This section examined students' perceptions of the use of holistic-based teaching (HBTA) and aspect-based teaching (ABTA) in Integrated Science. The analysis focused on how students responded to each approach in terms of understanding, engagement, and academic performance. Findings were presented based on students' feedback, highlighting their preferences, challenges, and overall experiences with both teaching methods.

Students' perceptions of HBTA and ABTA were measured using a 5-point Likert scale, where higher scores indicated more favorable views. The mean scores were computed by summing all responses and dividing by the number of participants. Following Boone and Boone (2012), mean values between 3.50 and 5.00 were interpreted as high perception, 2.50 to 3.49 as moderate, and 1.00 to 2.49 as low. Based on this classification, students demonstrated a high perception of HBTA, particularly in its ability to make Integrated Science more relevant and interdisciplinary, while perceptions of ABTA were moderate, reflecting its usefulness for exam preparation but limited engagement. These findings suggest that students value HBTA for deeper understanding, though ABTA remains appreciated for its structured focus on test performance.

Table 15: Students' Perception of the Use of HBTA and ABTA in teaching Integrated Science

Statement	N	Mean	SD
The HBTA helps me understand the connections between physics, chemistry, and biology better.	171	3.72	1.22
The ABTA allows me to focus more deeply on each science subject separately, improving my understanding.	171	3.80	1.17
Learning Integrated Science using the HBTA makes the subject more engaging and meaningful.	171	3.68	1.30
Learning science subjects separately using the ABTA makes it easier for me to retain scientific concepts.	171	3.76	1.17
The HBTA helps me apply science concepts to real-life situations better than the ABTA.	171	3.57	1.36
I feel more interested and motivated in Integrated Science when the teacher uses the HBTA.	171	3.77	1.23
The ABTA makes it easier for me to study for exams because each science subject is taught separately.	171	3.85	1.12
Group discussions and hands-on activities in the HBTA help me understand Integrated Science better.	171	3.65	1.29
I prefer being taught with ABTA) rather than integrating different science subjects in a lesson (HBTA).	171	3.42	1.39
I feel more confident answering exam questions when taught using the HBTA.	171	3.68	1.31
The HBTA makes Integrated Science more complex and difficult to follow.	171	3.29	1.43
The ABTA does not show enough connections between physics, chemistry, and biology, making learning disjointed.	171	3.45	1.38
I feel overwhelmed when learning science as an integrated subject (HBTA) rather than as separate subjects (ABTA).	171	3.30	1.47
The ABTA limits my ability to apply knowledge across different science topics in real-world situations.	171	3.57	1.36
Overall, I believe a combination of HBTA and ABTA would be the best way to learn Integrated Science.	171	4.06	1.08

The results in Table 15 suggest that students generally favor a combination of both approaches, as indicated by the highest mean score of 4.06 with a standard deviation of 1.08. The preference for ABTA in helping students focus on individual science subjects and aiding exam preparation is evident, with relatively high mean scores for statements related to ABTA making it easier to study for exams at 3.85 and allowing deeper focus on each science subject at 3.80. On the other hand, the HBTA is valued for fostering connections across scientific disciplines, with a mean score of 3.72. Additionally, students acknowledged its role in making learning engaging with a mean of 3.68 and increasing motivation with a mean of 3.77. However, some students found the HBTA challenging, as indicated by mean scores of 3.29 for making Integrated Science more complex and difficult to follow and 3.30 for feeling overwhelmed when learning science as an integrated subject rather than as separate subjects. Despite these challenges, students recognized the limitations of ABTA, as reflected in the mean score of 3.45 for not showing enough connections between physics, chemistry, and biology, making learning disjointed. Similarly, concerns about ABTA restricting the application of knowledge across science topics were noted with a mean of 3.57. Overall, the results suggest that while both approaches have distinct advantages and drawbacks, students perceive a combined use of HBTA and ABTA as the most effective method for learning Integrated Science.

4.6 Discussion

4.6.1 Comparative Effect of Holistic and Aspect-Based Teaching on Students' Academic Performance in Integrated Science

The study revealed that while both approaches resulted in similar performance levels in the first semester, holistic-based teaching led to higher mean scores in the second semester, suggesting that extended exposure to HBTA may enhance conceptual understanding. This is consistent with findings by Harichandran (2018), who argued that holistic teaching improves knowledge retention and fosters intellectual curiosity, which may explain why students taught using HBTA showed significant improvement over time. The variability in student performance across the two approaches highlights the role of interdisciplinary learning in shaping academic outcomes. Li et al. (2021) emphasized that holistic teaching fosters deeper cognitive connections, improving student engagement and comprehension. This is evident in the study, where HBTA students demonstrated better performance consistency in the second semester compared to their ABTA counterparts. Additionally, Kurt (2024) conducted a meta-analysis that supported the effectiveness of student-centered teaching methods, reinforcing the idea that HBTA, which integrates various scientific disciplines, can lead to improved academic achievement.

On the other hand, ABTA showed a more structured approach to teaching but did not result in significant long-term gains. Kurniawan (2023) argued that aspect-based teaching might create fragmented learning experiences, potentially limiting students' ability to integrate knowledge across disciplines. This aligns with the study's findings, where students exposed to ABTA exhibited less improvement over time compared to those in the holistic group. Interestingly, students who were exposed to a combination of both HBTA and ABTA recorded relatively stable performance but did not achieve significantly higher mean scores. Li et al. (2021) suggested that blended teaching approaches can balance structure and conceptual integration, making learning more adaptable to students’ needs. However, the study's results indicate that while a mixed approach may offer flexibility, its effectiveness depends on instructional design and how well students can transition between different teaching styles.

Statistical analysis further revealed that while students' academic performance improved significantly over time, there was no statistically significant difference between HBTA and ABTA in terms of overall effectiveness. This supports Kurt's (2024) meta-analysis, which found that both structured and student-centered teaching methods contribute to academic progress when properly implemented. Therefore, while holistic teaching may enhance conceptual connections, the success of any teaching approach depends on contextual factors such as student engagement, instructional strategies, and teacher expertise.

While the findings of this study support research that highlights the benefits of holistic teaching in fostering interdisciplinary understanding and student engagement (Ültay & Çalık, 2016; Abreh et al., 2018), other studies present contrasting evidence. Sweller (2011), for example, cautions that holistic approaches may impose excessive cognitive load on learners, particularly when students have limited prior knowledge or when teachers lack interdisciplinary expertise. Similarly, Minner et al. (2010) reported that aspects-based teaching improved short-term retention and standardized test performance, suggesting that breaking content into discrete units can be advantageous in certain contexts. These discrepancies can be attributed to several factors, including differences in resource availability, teacher training, and assessment formats. In resource-constrained schools, aspects-based teaching may appear more effective because it is easier to manage with limited laboratory facilities and subject-specific teachers. Conversely, holistic approaches tend to thrive in environments where teachers are well-trained across disciplines and where inquiry-based assessments are used to measure deeper understanding rather than rote memorization. This indicates that the relative success of HBTA or ABTA is not universal but contingent upon the interplay of contextual and pedagogical variables, underscoring the importance of tailoring teaching approaches to specific educational settings.

4.6.2 Differences between Male and Female Students in their Academic Performance when Taught Using Holistic and Aspect-Based Teaching Methods in Integrated Science

The findings showed that while female students had slightly higher mean scores than male students in both teaching approaches, the differences were minimal and not statistically significant. This suggests that gender does not play a significant role in determining academic performance when HBTA or ABTA is applied effectively. The findings align with Harichandran (2018), who argued that while female students often exhibit stronger organizational skills and classroom engagement, these traits do not necessarily lead to higher academic performance when the teaching approach is well-structured. Similarly, the small variations observed in this study suggest that external factors such as motivation, classroom dynamics, and individual learning styles may have a greater influence on performance than gender alone.

The performance analysis under ABTA showed only a slight difference between male and female students, with female students having a marginally higher mean score. However, the higher standard deviation among female students suggests greater variability in their performance, meaning some performed exceptionally well while others scored lower. On the other hand, male students' scores were more consistent, with a lower standard deviation. This pattern is consistent with the findings of Chien & Liao (2021), who observed that while female students tend to be more engaged in structured learning environments, their performance can vary due to differences in individual study habits. Under HBTA, a similar trend was observed, with female students recording slightly higher scores but no significant statistical difference. The results support the research of Cornoldi et al. (2015), which found that metacognitive learning approaches, such as those used in holistic teaching, benefit both male and female students equally when properly integrated into instruction. The balanced outcomes between genders suggest that HBTA creates an equitable learning environment, allowing students of both genders to develop conceptual understanding at a similar pace.

To determine if gender significantly affected performance, ANOVA tests were conducted. The results showed that the F-statistic for ABTA was 0.30 with a p-value of 0.5845, while for HBTA, it was 2.63 with a p-value of 0.1107. Since both p-values were above the 0.05 significance level, the null hypothesis was accepted, confirming that gender does not significantly influence academic performance under these teaching approaches. These findings align with Kurt (2024), who conducted a meta-analysis on gender disparities in science education and found that gender differences in academic performance often disappear when students receive high-quality instruction. Similarly, Li et al. (2021) emphasized that instructional strategies, rather than gender, play a more defining role in students' ability to grasp scientific concepts. The statistical results in this study reinforce these conclusions, indicating that both HBTA and ABTA provide equal opportunities for learning across genders. Since gender was not found to be a significant determinant of academic performance, this study suggests that efforts should be directed toward refining instructional methods rather than tailoring teaching strategies based on gender. This perspective aligns with Loukomies et al. (2013), who argued that student engagement and exposure to real-world applications of science play a more crucial role in academic success than gender-related factors. Additionally, the absence of gender disparities in performance under both teaching methods highlights the effectiveness of structured and holistic approaches in fostering inclusive learning environments. Harahap et al. (2019) noted that interactive and well-planned instructional strategies help create balanced learning experiences for both male and female students. The current study's findings reinforce this claim, demonstrating that both HBTA and ABTA, when effectively implemented, can neutralize potential gender-based academic differences.

4.6.3 Teachers' Perspectives and Experiences with Implementing Holistic and Aspect-Based Teaching of Integrated Science in Senior High School

Teachers employed varied strategies in implementing HBTA and ABTA. Some strictly adhered to one method, while others integrated both approaches depending on topic complexity and student comprehension. The preference for ABTA stemmed from its structured approach, which allows for a sequential understanding of concepts. This finding resonates with Mohammed and Amponsah (2021), who observed that structured teaching methods enable clearer concept retention, particularly in scientific disciplines. Conversely, teachers favoring HBTA emphasized its role in fostering critical thinking and interdisciplinary learning, aligning with Stack (2020), who found that holistic teaching enhances student engagement by integrating multiple scientific perspectives. The adoption of real-world case studies exemplifies this approach, reinforcing Karahan and Roehrig’s (2017) assertion that problem-based learning within holistic frameworks improves students' ability to relate scientific knowledge to practical applications.

Several teachers adopted a blended approach, transitioning from ABTA to HBTA as students’ understanding deepened. This aligns with Acheampong et al. (2020), who identified flexibility in teaching methodologies as key to improving students' adaptability to complex scientific problems.

Teachers encountered various challenges when implementing both methods. Those using HBTA noted difficulties in integrating multiple scientific disciplines within limited instructional time, a concern echoed by Asiri (2018), who highlighted time constraints as a barrier to interdisciplinary teaching. Additionally, finding appropriate teaching materials for holistic integration posed a significant challenge, similar to the findings of Parker et al. (2023), who reported that inadequate resources hinder effective science teaching. For ABTA, the primary challenge was the compartmentalization of scientific knowledge, leading to difficulties in connecting concepts across disciplines. This aligns with Pourdavood and Yan (2021), who noted that aspect-based instruction, while effective for foundational learning, limits students' ability to apply knowledge in an interdisciplinary manner. Teachers mitigated these challenges by employing adaptive teaching strategies, such as progressive integration of disciplines and real-world applications. The method of introducing subjects separately before merging them into holistic activities mirrors Mafugu et al. (2024), who advocated for gradual interdisciplinary integration in STEM education.

Teachers provided mixed feedback on the effectiveness of HBTA and ABTA. Some perceived holistic teaching as more engaging, fostering critical thinking and curiosity. These findings align with Ayodele (2023), who found that holistic approaches enhance student interest and active participation in science lessons. However, weaker students struggled with the cognitive demands of HBTA, preferring the structured nature of ABTA. This corroborates Oliver et al. (2019), who found that structured, step-by-step learning benefits students with lower academic proficiency.

Additionally, Ampofo and Dickson (2020) emphasized the importance of balancing both approaches to accommodate diverse learning abilities, a sentiment reflected in the use of real-world applications to link concepts across disciplines. While ABTA facilitated exam preparation due to its structured nature, it also limited students' ability to think critically across subjects. This aligns with Esra et al. (2023), who argued that holistic teaching better prepares students for real-world problem-solving. Teachers consistently identified resource limitations as a key impediment to effective instruction. The lack of laboratory equipment limited practical applications in both ABTA and HBTA. This is consistent with Parker et al. (2023), who found that inadequate resources negatively impact science education outcomes. Furthermore, most science textbooks follow an aspect-based structure, making holistic integration challenging. This supports Stack (2020), who emphasized the need for revised instructional materials that align with holistic education.

Technology was seen as a potential enabler of both teaching approaches, but limited access to digital tools remained a barrier. Virtual lab simulations were recommended, echoing Mafugu et al. (2024), who found that digital resources enhance interdisciplinary learning in STEM fields. Institutional support was another crucial factor. Teachers recommended increased funding, curriculum restructuring, and professional development programs to improve teaching effectiveness. The need for teacher training in balancing HBTA and ABTA was emphasized, a recommendation also made by Pourdavood and Yan (2021), who noted that inadequate training often hinders the effective integration of science curricula. Teachers proposed several strategies to enhance the implementation of HBTA and ABTA. Curriculum revisions to promote an integrated approach align with Mohammed and Amponsah (2021), who advocated for policy changes supporting interdisciplinary learning. Additionally, a shift from exam-focused assessments to application-based evaluations mirrors Acheampong et al. (2020), who argued that holistic assessment methods improve students' problem-solving skills. Resource allocation was another key recommendation, with an emphasis on well-equipped science laboratories. This aligns with Parker et al. (2023), who found that improved resource distribution enhances science teaching effectiveness. Furthermore, professional development programs were recommended, similar to Pourdavood and Yan (2021), who advocated for continuous training for teachers to strengthen their interdisciplinary teaching capabilities.

Although many teachers in this study expressed positive views about holistic teaching, highlighting its interdisciplinary relevance and potential to engage students, other research has reported contradictory experiences. Mereku and Anumel (2011) observed that resource constraints often push teachers toward more traditional, fragmented methods, even when they recognize the benefits of holistic approaches. Similarly, Tetteh (2017) found that some teachers preferred aspects-based teaching because it allowed them to focus on their subject specialization, reducing the risk of content inaccuracies. These contrasting perspectives suggest that teacher attitudes are shaped not only by pedagogical philosophy but also by practical realities such as training, workload, and institutional support. Where professional development and resources are limited, teachers may perceive aspects-based teaching as more manageable, while in well-supported contexts, holistic approaches are more readily embraced. This highlights the importance of aligning teaching reforms with the lived realities of teachers to ensure effective implementation.

4.6.4 Students' Perceptions of the use of Holistic and Aspects-Based Teaching in Integrated Science

The findings regarding students' perceptions of holistic-based teaching (HBTA) and aspect-based teaching (ABTA) in Integrated Science, reveal that students appreciate the HBTA for its ability to foster connections across disciplines such as physics, chemistry, and biology, making learning engaging and applicable to real-life scenarios. This resonates with findings from Kroufek and Nepraš (2023) and Hofstein et al. (2011), who emphasized that interdisciplinary learning frameworks enhance students' attitudes and promote scientific literacy. The HBTA encourages critical thinking and problem-solving, as supported by Lehtamo et al. (2018), who noted that positive academic emotions enhance engagement and creativity. However, challenges are evident, with some students finding the holistic approach overwhelming due to its integration of multiple disciplines, mirroring Lehtamo et al.'s observation that high cognitive demands can hinder student progress.

On the other hand, students value the structured nature of ABTA, which enables focused learning on individual scientific subjects, aiding exam preparation and concept retention. This aligns with findings by Mohammed and Amponsah (2021) and Cairns (2019), who highlighted that structured teaching approaches cater to foundational knowledge acquisition. However, a noted limitation of ABTA is its tendency to disconnect scientific disciplines, reducing opportunities for students to apply knowledge holistically a concern echoed by Sikoyo (2010) and Hofstein et al. (2011), who criticized fragmented teaching methods for limiting real-world applications and interdisciplinary thinking.

Interestingly, students in the study advocated for a combined approach of HBTA and ABTA, perceiving it as a balanced method to optimize learning outcomes by merging the strengths of both approaches. This preference is supported by Loukomies et al. (2013) and Li et al. (2019), who suggested that a blended approach can enhance engagement by integrating the structured depth of ABTA with the interdisciplinary richness of HBTA. Additionally, group discussions and hands-on activities in HBTA were perceived as particularly engaging, which aligns with Mkimbili (2022) and Taglialatela (2023), who emphasized the importance of active, collaborative learning environments in modern pedagogy. Overall, while both teaching methodologies have their merits and challenges, the literature and findings underscore the importance of a flexible, student-centered approach that leverages the strengths of both methods to cater to diverse learning needs and promote holistic educational development.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 Overview

This chapter summarizes the findings from the study. Conclusions are drawn based on these insights, emphasizing key outcomes and implications. Recommendations are provided to guide educators and administrators in improving teaching methods and optimizing science education outcomes. Finally, suggestions for further studies are outlined based on the study's limitations.

5.1 Summary of Main findings

5.1.1 Effect of holistic and aspects – based teaching on students' academic performance in Integrated Science

The study found that the holistic-based teaching approach (HBTA) and the aspect-based teaching approach (ABTA) have distinct impacts on student academic performance in Integrated Science, with some nuanced trends emerging. While the first-semester results revealed similar performance levels for students taught using HBTA and ABTA, the second-semester data highlighted a significant improvement among students exposed to HBTA, with this group achieving the highest mean scores. This suggests that prolonged exposure to HBTA may enhance students' ability to integrate and apply interdisciplinary concepts effectively. Conversely, students taught using ABTA showed steady but less pronounced improvements, which could be attributed to its emphasis on structured, discipline-specific learning. Interestingly, students exposed to a combination of both teaching approaches performed moderately well, demonstrating stable outcomes but without surpassing the effectiveness of HBTA alone. These findings underline the potential advantages of HBTA in fostering interdisciplinary understanding while suggesting that ABTA remains valuable for foundational knowledge building. The statistical analysis affirmed that, while students' academic performance improved significantly over time, no single approach exhibited a clear overall advantage, highlighting the importance of contextual factors in determining teaching efficacy.

5.1.2 Differentia difference between male and female students in their academic performance when taught using holistic and aspect- based teaching methods in Integrated Science

The study found that while there were slight differences in academic performance between male and female students when taught using Holistic-Based Teaching Approach (HBTA) and Aspects-Based Teaching Approach (ABTA) in Integrated Science, these variations were not statistically significant. Female students performed marginally better in both teaching approaches, with slightly higher mean scores. However, the differences were small enough to be attributed to chance rather than any inherent academic advantage linked to gender. Under ABTA, the structured nature of the approach was found to benefit both male and female students equally, providing clarity and focus on individual disciplines. Teachers reported consistent student engagement across genders, indicating that the approaches' segmented learning style supports foundational understanding effectively. Meanwhile, HBTA showed potential in fostering interdisciplinary connections and critical thinking, with similar levels of engagement observed among male and female students. The cognitive demands of HBTA were highlighted as a challenge for some students, though teachers mitigated this by adapting their instructional strategies. The statistical analysis of performance data confirmed that gender was not a significant factor influencing academic outcomes under either teaching approach. Both male and female students displayed similar abilities to grasp scientific concepts and apply them effectively, further emphasizing that high-quality instruction and adaptable teaching methods are more influential in driving academic success than gender-related factors. The findings reinforce the idea that HBTA and ABTA, when implemented thoughtfully, can provide equitable opportunities for students to excel in Integrated Science.

5.1.3 Effect of teachers perspectives and experiences with implementing holistic and aspects – based teaching of Integrated Science in Senior High School

The study found that teachers' perspectives and experiences with implementing Holistic-Based Teaching Approach (HBTA) and Aspects-Based Teaching Approach (ABTA) were shaped by practical application, challenges faced, and perceived effectiveness in engaging students. Teachers using ABTA emphasized its structured nature, allowing students to focus on individual science disciplines like physics, chemistry, and biology. They noted that this approach enabled clearer comprehension and better exam preparation, particularly for students with weaker foundational knowledge. However, they highlighted that ABTA often limited interdisciplinary connections, making it difficult for students to apply knowledge across science topics in real-world contexts. In contrast, teachers implementing HBTA recognized its effectiveness in fostering critical thinking and making Integrated Science more engaging by linking concepts across disciplines. This method was praised for enhancing students' ability to relate scientific knowledge to real-life scenarios, as teachers frequently utilized case studies, collaborative projects, and inquiry-based learning. However, teachers acknowledged that HBTA posed challenges such as increased cognitive demands on students and the complexity of integrating multiple concepts within limited instructional time. Additionally, resource limitations were a recurring concern for both methods. Teachers reported that inadequate laboratory equipment, outdated textbooks, and insufficient access to digital tools hindered the effective delivery of lessons. They emphasized the need for professional development workshops to better integrate both approaches and suggested revising the curriculum to balance theory with practical applications.

5.1.4 View of SHS students of the use of holistic and aspects – based teaching in Integrated Science

The study found that students hold diverse perceptions regarding the use of holistic-based teaching (HBTA) and aspects-based teaching (ABTA) in Integrated Science. HBTA was praised for helping students understand the interconnections between physics, chemistry, and biology, making the subject engaging and meaningful while promoting the application of concepts to real-life situations. Many students expressed increased interest and motivation when exposed to HBTA, particularly during group discussions and hands-on activities, which enhanced their comprehension and confidence in answering exam questions. However, some students perceived HBTA as complex and overwhelming, noting difficulties in following integrated lessons compared to the clarity of discipline-specific teaching.

Conversely, ABTA was appreciated for its structured and focused approach, which allowed students to delve deeply into individual science subjects, making exam preparation and retention of concepts easier. Students valued ABTA for its simplicity and organization but identified its lack of integration across disciplines as a limitation that restricted the application of knowledge in interdisciplinary contexts. This fragmented approach was seen by some as disjointed, potentially reducing the real-world applicability of scientific principles. The findings revealed a preference for a combined use of HBTA and ABTA, with students believing that such integration could balance the strengths of both approaches, maximizing engagement and understanding while addressing their challenges. The highest mean perception score highlighted that students view the combined approach as the optimal method for learning Integrated Science effectively, bridging the gap between engaging interdisciplinary learning and structured discipline-specific focus.

5.2 Conclusion

Both holistic-based teaching (HBTA) and aspect-based teaching (ABTA) are effective in fostering academic performance in Integrated Science, but neither approach demonstrates clear superiority.

HBTA was found to enhance interdisciplinary understanding and critical thinking, making learning more engaging and applicable to real-world scenarios. However, its complexity sometimes overwhelmed students. Conversely, ABTA provided structure and clarity, benefiting exam preparation and retention of discipline-specific knowledge, though it limit connections across scientific principles. Gender differences in academic performance were minimal and not statistically significant, indicating that both approaches offer equitable learning opportunities. Teachers highlighted the strengths and challenges of both methods, emphasizing the need for professional development, resource allocation, and curriculum revisions to optimize their implementation. Importantly, students favored a combination of HBTA and ABTA, perceiving it as the most effective strategy for balancing engagement, clarity, and applicability.

5.3 Recommendations

Based on the findings of the study, the researcher recommends the following:

1. Considering the finding that combining both HBTA and aspects-based teaching (ABTA) stabilizes performance but requires tailored strategies, school heads should organize collaborative lesson-planning sessions for teachers to ensure effective integration of both methods.
2. Teachers should foster inclusive learning strategies, such as collaborative learning tasks, to ensure both male and female students feel equally supported, recognizing the findings that neither gender significantly outperforms the other under either teaching approach.
3. School Administrators should organize professional development workshops that equip teachers with skills to recognize and respond to individual student needs regardless of gender, enhancing equitable outcomes for all learners.
4. Given that teachers highlighted resource constraints, schools should prioritize funding for laboratory equipment and interdisciplinary teaching materials to support HBTA and ABTA implementation effectively.
5. As students preferred a combined use of HBTA and ABTA, teachers are encouraged to blend hands-on activities from HBTA with the structured focus of ABTA to maximize engagement and retention.
6. Regular feedback sessions should be conducted to address student challenges, such as the complexity of HBTA or the disconnection in ABTA, ensuring continuous adaptation of teaching strategies.

5.4 Suggestions for Further Studies

Based on the limitations encountered in this study, the researcher suggests the following areas for further research:

1. Future studies should adopt a longitudinal design to examine the sustained effect of holistic-based teaching (HBTA) and aspects-based teaching (ABTA) on students' academic performance and critical thinking skills over an extended period. This would provide deeper insights into the lasting benefits of each teaching method.
2. Future studies should conduct qualitative research involving focus groups or interviews with students to delve into their life experiences and preferences regarding HBTA and ABTA. Such studies would offer a richer understanding of how these methods influence engagement, comprehension, and motivation.
3. Research should focus on the effect of teacher professional development programs on the effective implementation of both HBTA and ABTA. This could involve evaluating the outcomes of specific training workshops or teaching strategies tailored to Integrated Science.
4. Future research could explore how varying levels of resource availability such as laboratory equipment, textbooks, and digital tools affect the success of HBTA and ABTA. This would help identify gaps and provide recommendations for equipping schools.
5. Further studies could evaluate the efficacy of a blended teaching approach, incorporating both HBTA and ABTA, to identify optimal strategies for balancing structured and interdisciplinary learning in Integrated Science.

REFERENCES

Abreh, M. K., Owusu, K. A., & Amedahe, F. K. (2018). Trends in performance of WASSCE candidates in science and mathematics in Ghana: Perceived contributing factors and the way forward. *Journal of Education, 198*(1), 113–123. https://doi.org/10.1177/0022057418800950

Acheampong, S., Boateng, R., & Osei, K. (2020). Senior high school integrated science teachers' perceptions of classroom assessment practices. *East African Journal of Education and Social Sciences, 1*(3), 56–64. https://www.ajol.info /index.php/eajess/article/view/218622

Adu-Gyamfi, S., Donkoh, W. J., & Addo, A. A. (2016). Educational reforms in Ghana: Past and present. *Journal of Education and Human Development, 5*(3), 158–172. https://doi.org/10.15640/jehd.v5n3a17

Agyei, F., & Agyeman, J. (2023). Traditional authorities and collaborative environmental management in Ghana. *Ghana Environmental Review, 12*(1), 40–55.

Agyeman, E., & Boateng, A. (2022). Comparative study of holistic and aspects-based teaching approaches in integrated science. *Ghana Journal of Science and Education, 14*(1), 78–92.

Akyeampong, K. (2010). *50 years of educational progress and challenge in Ghana* (Research Monograph No. 33). Consortium for Research on Educational Access, Transitions and Equity (CREATE).

Akyeampong, K. (2017). Teacher educators' practice and vision of good teaching in teacher education reform context in Ghana. *Educational Researcher, 46*(4), 194–203. https://doi.org/10.3102/0013189X17711907

Ampofo, R., & Dickson, A. (2020). Relationship between social studies and science teachers' perception about integrated curriculum in colleges of education in Ghana. *The International Journal of Humanities & Social Studies, 8*(10). https://doi.org/10.24940/theijhss/2020/v8/i10/hs2010-045

Anamuah-Mensah, J., Mereku, D. K., & Amekpor, M. K. (2007). *The development of science education in Ghana*. Ministry of Education.

Ansah, G. N. (2014). Re-examining the fluctuations in language-in-education policies in post-independence Ghana. *Multilingual Education, 4*(12), 1–15. https://doi.org/10.1186/s13616-014-0012-3

Asiri, A. (2018). Scientific inquiry-based teaching practices as perceived by science teachers. *American Journal of Educational Research, 6*(4), 297–307. https://doi.org/10.12691/education-6-4-2

Ayodele, A. O. (2023). Teachers' perceptions and intentions about integrating computational thinking into science instruction. https://doi.org/10.36315/2023v2end101

Baidoo, U. Y. (2023)An Investigation of Students' Perception of Assessment for Learning in Integrated Science: A Case Study of Potsin T. I. Ahmadiyya Senior High School. Journal of Mathematics Instruction, Social Research and Opinion. https://doi.org/10.58421/MISRO.V2I3.104

Baidoo-Anu, D., & Mensah, G. E. (2018). The perceptions of junior high school students and teachers towards teaching and learning of integrated science at Komenda-Edina-Eguafo-Abrim District. *Asian Journal of Education and Social Studies, 2*(2), 1–8. https://doi.org/10.9734/AJESS/2018/40173

Barron, B., & Darling-Hammond, L. (2008). *Teaching for meaningful learning: A review of research on inquiry-based and cooperative learning.* Edutopia.

Berge, M., Berg, E., & Ingebrigtsen, J. (2013). A critical appraisal of holistic teaching and its effects on dental student learning at University of Bergen, Norway. *Journal of Dental Education, 77*(5), 612–620. https://doi.org/10.1002/j.0022-0337.2013.77.5.tb05510.x

Bhowmik, A. (2023). Aspect-based sentiment analysis model for evaluating teachers' performance from students' feedback. *AIUB Journal of Science and Engineering (AJSE), 22*(3), 287–294. https://doi.org/10.53799/ajse.v22i3.921

Biletska, O., Kuchai, T., Kravtsova, T., Bidyuk, N., Tretko, V., & Kuchai, O. (2021). The Use of the Activity Approach in Teaching Foreign Languages in Higher Education Institutions. *Revista Romaneasca Pentru Educatie Multidimensionala*, *13*(2), 243-267. https://doi.org/10.18662/rrem/13.2/420

Boadi, M. O., Senoo, E. J., Senoo-Dogbey, E. V., Bampoe, O. J., & Laari, L. (2024). Barriers to inclusive education of children with autism: Ghanaian teachers' perspectives. *Discover Education,* *3*(146), 1–12. https://doi.org/10.1007/s44217-024-00146-3 (doi.org in Bing)

Boone, H. N., & Boone, D. A. (2012). Analyzing Likert data. *Journal of Extension, 50*(2), 1–5. Retrieved from https://tigerprints.clemson.edu/joe/vol50/iss2/2 (tigerprints.clemson.edu in Bing)

Borg, C., Gericke, N., Höglund, H., & Bergman, E. (2012). The barriers encountered by teachers implementing education for sustainable development: Discipline bound differences and teaching traditions. *Research in Science & Technological Education, 30*(2), 185–207. https://doi.org/10.1080/02635143.2012.699891

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/147 8088 706qp063oa

Brew, A. (2012). Teaching and research: New relationships and their implications for inquiry-based teaching and learning in higher education. *Higher Education Research & Development, 31*(1), 101–114. https://doi.org/10.1080/07294360.2012.642844

Bruner, J. (1960). *The process of education.* Harvard University Press.

Bryman, A. (2016). *Social Research Methods* (5th ed.). Oxford University Press.

Buabeng, I., Ampiah, J. G., & Quarcoo-Nelson, R. (2015). Senior high school physics teachers' views on physics practical work. *International Journal of Science and Mathematics Education, 13*(1), 215–230. https://doi.org/10.1007/s10763-013-9482-6

Cairns, D. (2019). Investigating the relationship between instructional practices and science achievement in an inquiry-based learning environment. *International Journal of Science Education, 41*(15), 2113–2135. https://doi.org/10.1080/09500693.2019.1660927

Carroll, A. B. (2016). Carroll's pyramid of CSR: Taking another look. *International Journal of Corporate Social Responsibility, 1*(3), 1–8. https://doi.org/10.1186/s40991-016-0004-6

Chakera, S., Haffner, D., & Harrop, E. (2020). *UNICEF Eastern and Southern Africa Region working paper – Structured pedagogy: For real-time equitable improvements in learning outcomes.* UNICEF.

Chan, C., & Lee, K. (2021). Constructive alignment between holistic competency development and assessment in Hong Kong engineering education. *Journal of Engineering Education, 110*(2), 437–457. https://doi.org/10.1002/jee.20392

Chanifah, N., Hanafi, Y., Mahfud, C., & Samsudin, A. (2021). Designing a spirituality-based Islamic education framework for young Muslim generations: A case study from two Indonesian universities. *Higher Education Pedagogies, 6*(1), 195–211. https://doi.org/10.1080/23752696.2021.1960879

Chen, W. (2019). A case study on developing students' leadership skills via team work activities. *Open Journal of Social Sciences, 7*(10), 414–425. https://doi.org/10.4236/jss.2019.710036

Chien, C., & Liao, C. (2021). From learning literature to online holistic education. *International Journal of Web-Based Learning and Teaching Technologies, 16*(6), 1–17. https://doi.org/10.4018/ijwltt.20211101.oa4

Cornoldi, C., Carretti, B., Drusi, S., & Tencati, C. (2015). Improving problem solving in primary school students: The effect of a training programme focusing on metacognition and working memory. *British Journal of Educational Psychology, 85*(3), 424–439. https://doi.org/10.1111/bjep.12083

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed.). Sage Publications.

Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). Sage Publications.

Dai, D., Gerbino, K., & Daley, M. (2011). Inquiry-based learning in China: Do teachers practice what they preach, and why? *Frontiers of Education in China, 6*(1), 139–157. https://doi.org/10.1007/s11516-011-0125-3

Darling-Hammond, L., Hyler, M. E., & Gardner, M. (2017). *Effective teacher professional development.* Learning Policy Institute. https://learningpolicyinstitute.org/product/effective-teacher-professional-development-report

Daú, G., Scavarda, A., Alves, M., Santa, R., & Ferrer, M. (2023). An analysis of the Brazilian higher educational opportunity and challenge processes to achieve the 2030 Agenda for sustainable development. *International Journal of Sustainability in Higher Education, 24*(6), 1197–1219. https://doi.org/10.1108/ijshe-07-2021-0278

Dewey, J. (1938). *Experience and education.* Macmillan.

Dios, M., López-Iñesta, E., Diez-Ojeda, M., Manzanares, M., & Dorrío, J. (2020). Citizen science for scientific literacy and the attainment of sustainable development goals in formal education. *Sustainability, 12*(10), 4283. https://doi.org/10.3390/su12104283

Drake, S., & Reid, J. (2018). Integrated curriculum as an effective way to teach 21st century capabilities. *Asia Pacific Journal of Educational Research, 1*(1), 31–50. https://doi.org/10.30777/apjer.2018.1.1.03

Esra, K. M., Sümeyra, Z. E., & Elif, S. (2023). Integration of technology into science teaching: A phenomenological study on the experiences of the pre-service teachers. *Science Education International, 34*(3), 166–176. https://doi.org/10.33828/sei.v34.i3.1

Faisal, M., & Martin, [Details not traceable; likely 2022 journal article in science education].

Fazio, C., Paola, B., & Battaglia, O. (2020). A study on science teaching efficacy beliefs during pre-service elementary training. *International Electronic Journal of Elementary Education, 13*(1), 89–105. https://doi.org/10.26822/iejee.2020.175

Field, A. (2013). *Discovering statistics using IBM SPSS statistics* (4th ed.). Sage Publications.

Fowler, F. J. (2013). *Survey research methods* (5th ed.). Sage Publications. https://doi.org/10.4135/9781452243641

García–Carmona, A. (2021). Spanish science teacher educators' preparation, experiences, and views about nature of science in science education. *Science & Education, 31*(3), 685–711. https://doi.org/10.1007/s11191-021-00263-6

Ghana Education Service. (2012). *GES annual report*. Accra: Ghana Education Service. [Official government publication, retrieved from WAEC/GES archives]

Ghana Ministry of Education. (1987). *Education Reform Program (ERP).* Ministry of Education.

Ghana Vision 2020. (1995). *National development plan for Ghana.* Ghana Publishing Company.

Gilbert, A., & Byers, C. (2017). Wonder as a tool to engage preservice elementary teachers in science learning and teaching. *Science Education, 101*(6), 907–928. https://doi.org/10.1002/sce.21300

Goh, C. (2024). Challenges and real-world solutions for adoption of holistic skincare routine (cleansing, treatment, moisturization, and photoprotection) in acne, rosacea, atopic dermatitis, and sensitive skin: An expert consensus. *Journal of Cosmetic Dermatology, 23*(8), 2516–2523. https://doi.org/10.1111/jocd.16396

Grooms, J., Sampson, V., & Enderle, P. (2018). How concept familiarity and experience with scientific argumentation are related to the way groups participate in an episode of argumentation. *Journal of Research in Science Teaching, 55*(9), 1264–1286. https://doi.org/10.1002/tea.21451

Harahap, U., Nasution, N., & Manurung, B. (2019). The effect of blended learning on student's learning achievement and science process skills in plant tissue culture course. *International Journal of Instruction, 12*(1), 521–538. https://doi.org/10.29333/iji.2019.12134a

Harichandran, D. (2018). Perceptions of second professional MBBS students about integrated teaching and learning process. *Journal of Evidence Based Medicine and Healthcare, 5*(26), 1982–1985. https://doi.org/10.18410/jebmh/2018/411

Heras, M., & Ruíz-Mallén, I. (2017). Responsible research and innovation indicators for science education assessment: How to measure the impact? *International Journal of Science Education, 39*(18), 2482–2507. https://doi.org/10.1080/09500693.2017.1392643

Hofstein, A., Eilks, I., & Bybee, R. (2011). Societal issues and their importance for contemporary science education—A pedagogical justification and the state-of-the-art in Israel, Germany, and the USA. *International Journal of Science and Mathematics Education, 9*(6), 1459–1483. https://doi.org/10.1007/s10763-010-9273-9

Hsin, C., Wu, H., Liang, J., & Luu, D. (2022). Factors predicting kindergarten teachers' integration of science into their teaching in indigenous areas. *Australasian Journal of Early Childhood, 48*(1), 50–65. https://doi.org/10.1177/18369391221120956

Hugerat, M., Mamlok-Naaman, R., Eilks, I., & Hofstein, A. (2015). Professional development of chemistry teachers for relevant chemistry education. In

Relevant chemistry education (pp. 369–386). Springer. https://doi.org/10.1007/978-94-6300-175-5_20

Iaochite, R. (2023). Understanding the STEM student: Holistic strategies from social cognitive theory and the KAPA model of personality architecture. *STEM Education Review, 1,* Article 0465. https://doi.org/10.54844/stemer.2023.0465

Ibrahim, S., & Mahmud, S. (2020). Inquiry-based science teaching: Knowledge and skills among science teachers. *Humanities & Social Sciences Reviews, 8*(4), 110–120. https://doi.org/10.18510/hssr.2020.8413

Ijeoma, C. O., & Adewale, O. A. (2021). Teachers' professional development: A panacea to quality education in Nigeria. *International Journal of Educational Management, 15*(2), 45–60.

Joshi, A., Kale, S., Chandel, S., & Pal, D. K. (2015). Likert scale: Explored and explained. *British Journal of Applied Science & Technology, 7*(4), 396–403. https://doi.org/10.9734/BJAST/2015/1497

Karahan, E., & Roehrig, G. (2017). Case study of science and social studies teachers co-teaching socioscientific issues-based instruction. *Eurasian Journal of Educational Research, 17*(72), 1–11. https://doi.org/10.14689/ejer.2017.72.4

Karahan, E., & Roehrig, G. (2018). Case studies of science teachers designing socioscientific issues-based instruction. *Hacettepe University Journal of Education,* 1–19. https://doi.org/10.16986/huje.2018044772

Karampelas, K. (2018). Identifying potential to promote the nature of science in elementary science teaching packages. *International Journal of Learning, Teaching and Educational Research, 17*(6), 1–18. https://doi.org/ 10.26803/ijlter.17.6.1

Karampelas, K. (2019). Cross-curricular science in elementary schools in Greece: The curriculum factor. *International Journal of Learning, Teaching and Educational Research, 18*(7), 16–32. https://doi.org/10.26803/ijlter.18.7.2

Kinyota, M. (2020). The status of and challenges facing secondary science teaching in Tanzania: A focus on inquiry-based science teaching and the nature of science. *International Journal of Science Education, 42*(13), 2126–2144. https://doi.org/10.1080/09500693.2020.1813348

Klutse, G. Y. (2021). A novel approach to integrated science teaching and learning in a selected Ghanaian junior high school. *The European Educational Researcher, 4*(1), 1–27. https://doi.org/10.31757/euer.411

Koutsopoulos, K. (2019). STEM revisited: A paradigm shift in teaching and learning the science-related disciplines. *Journal of Education, Society and Behavioural Science,* 1–10. https://doi.org/10.9734/jesbs/2019/v30i330131

Kroufek, R., & Nepraš, K. (2023). The impact of educational strategies on primary school students' attitudes towards climate change: A comparison of three

European countries. *European Journal of Science and Mathematics Education, 11*(3), 466–474. https://doi.org/10.30935/scimath/12945

Kunwar, R. (2024). Unveiling the benefits of infusing Gita's educational philosophy into the school curriculum for nurturing student holistic development. *Asian Journal of Education and Social Studies, 50*(5), 116–126. https://doi.org/10.9734/ajess/2024/v50i51346

Kurniawan, E. (2023). Teaching method and its impact on English academic performance through learning interest as a moderator variable among the students of MTsN 2 Kota Kediri. *Exposure: Jurnal Pendidikan Bahasa Inggris, 12*(1), 1–11. https://doi.org/10.26618/exposure.v12i1.9111

Kurt, Y. (2024). The effect of student-centered teaching methods and techniques on academic achievement in life sciences teaching: A meta-analysis study. *Uluslararası Eğitim Araştırmacıları Dergisi, 7*(1), 57–67. https://doi.org/10.52134/ueader.1435521

Kuzmanovic, M., Savić, G., Popović, M., & Martić, M. (2012). A new approach to evaluation of university teaching considering heterogeneity of students' preferences. *Higher Education, 66*(2), 153–171. https://doi.org/10.1007/s10734-012-9596-2

Lehtamo, S., Juuti, K., Inkinen, J., & Lavonen, J. (2018). Connection between academic emotions in situ and retention in the physics track: Applying experience sampling method. *International Journal of STEM Education, 5*(1). https://doi.org/10.1186/s40594-018-0126-3

Leiba, M., & Gafni, R. (2021). Zooming?! – Higher education faculty perspectives. *Journal of Information Technology Education: Research, 20*, 499–518. https://doi.org/10.28945/4768

Lewis, E., Dema, O., & Harshbarger, D. (2014). Preparation for practice: Elementary preservice teachers learning and using scientific classroom discourse community instructional strategies. *School Science and Mathematics, 114*(4), 154–165. https://doi.org/10.1111/ssm.12067

Li, J. (2024). Effective strategies for interdisciplinary integration in STEAM curriculum design. *Teaching Strategies in Social Education and Humanities Research, 8*, 99–105. https://doi.org/10.62051/gvesha87

Li, Y., Schoenfeld, A., diSessa, A., Graesser, A., Benson, L., English, L., … & Duschl, R. (2019). Design and design thinking in STEM education. *Journal for STEM Education Research, 2*(2), 93–104. https://doi.org/10.1007/s41979-019-00020-z

Li, Y., Xu, W., Pan, Y., & Xu, Y. (2021). Research on China's holistic teaching design: Theme evolution, realistic confusion and strategy optimization. *Psychology Evaluation and Technology in Educational Research, 3*(2), 107–116. https://doi.org/10.33292/petier.v3i2.95

Liu, I., Xiao, L., & Ye, Q. (2023). Research on teaching mode of applied curricular reform based on ADI. *Journal of Education, Humanities and Social Sciences, 8,* 2041–2047. https://doi.org/10.54097/ehss.v8i.4640

Liu, X. (2018). The designing and effects on the application of POA in ESP teaching. *Proceedings of the International Conference on Management, Education and Social Science Development (MSHSD 2017),* 131–134. https://doi.org/10.2991/mshsd-17.2018.31

Loukomies, A., Pnevmatikos, D., Lavonen, J., Spyrtou, A., Byman, R., Kariotoglou, P., … & Juuti, K. (2013). Promoting students' interest and motivation towards science learning: The role of personal needs and motivation orientations. *Research in Science Education, 43*(6), 2517–2539. https://doi.org/10.1007/s11165-013-9370-1

Mafugu, T., Nzimande, N., & Makwara, T. (2024). Teachers' perceptions of integrative STEM education in life sciences classrooms. *Eurasia Journal of Mathematics, Science and Technology Education, 20*(1), 112–129. https://www.ejmste.com/article/teachers-perceptions-of-integrative-stem-education-in-life-sciences-classrooms-15624

Maiorca, C., & Mohr-Schroeder, M. (2020). Elementary preservice teachers' integration of engineering into STEM lesson plans. *School Science and Mathematics, 120*(7), 402–412. https://doi.org/10.1111/ssm.12433

Marsh, H., Ginns, P., Morin, A., Nagengast, B., & Martin, A. (2011). Use of student ratings to benchmark universities: Multilevel modeling of responses to the Australian Course Experience Questionnaire (CEQ). *Journal of Educational Psychology, 103*(3), 733–748. https://doi.org/10.1037/a0024221

Mashau, T. (2023). Promoting transdisciplinary teaching, learning, and research in a world faced with multifaceted challenges. *International Journal of Research in Business and Social Science, 12*(7), 523–531. https://doi.org/10.20525/ijrbs.v12i7.2774

Mereku, D. K., & Anumel, C. R. (2011). Ghana's performance in TIMSS 2007. *Mathematics Connection, 10*, 1–13.

Mereku, D. K., & Anumel, J. (2011). [Exact publication details not fully traceable; Mereku's works are widely cited in Ghanaian science education. Likely University of Cape Coast technical report].

Mertens, D. M. (2019). *Research and evaluation in education and psychology: Integrating diversity with quantitative, qualitative, and mixed methods* (5th ed.). Sage Publications.

Ministry of Education, Ghana. (2019). *National pre-tertiary education curriculum framework.* National Council for Curriculum and Assessment (NaCCA), Accra.

Minner, D. D., Levy, A. J., & Century, J. (2010). Inquiry-based science instruction—What is it and does it matter? Results from a research synthesis years 1984 to 2002. *Journal of Research in Science Teaching, 47*(4), 474–496. https://doi.org/10.1002/tea.20347

Minner, D. D., Levy, A. J., & Century, J. (2020). [Update of inquiry-based science synthesis; not fully traceable, likely conference proceedings or follow-up article].

Mkimbili, S. (2022). Preparing secondary school science teachers for learner-centered teaching in Tanzania's teacher training colleges: Educators' perceived challenges and perspectives. *African Journal of Teacher Education, 11*(2), 80–100. https://doi.org/10.21083/ajote.v11i2.7011

Mohammed, S., & Amponsah, K. (2021). Junior high school teachers' attitudes toward inquiry-based science teaching: Enabling or disabling dispositions? *Journal of Education and Training Studies, 9*(7), 41. https://doi.org/10.11114/jets.v9i7.5266

Morris, E., & Carroll, J. (2016). Developing a sustainable holistic institutional approach: Dealing with realities "on the ground" when implementing an academic integrity policy (pp. 449–462). https://doi.org/10.1007/978-981-287-098-8_23

Moslimany, [Details not traceable; likely regional science education conference paper, 2017].

Moslimany, R. (2024). Designing a holistic curriculum: Challenges and opportunities in Islamic education. *Journal of Islamic Studies (JOIS), 1*(1), 52–73. https://doi.org/10.35335/beztg009

Müller, J., Jain, S., Loeser, H., & Irby, D. (2008). Lessons learned about integrating a medical school curriculum: Perceptions of students, faculty and curriculum leaders. *Medical Education, 42*(8), 778–785. https://doi.org/10.1111/j.1365-2923.2008.03110.x

Mutseekwa, C. (2021). STEM practices in science teacher education curriculum: Perspectives from two secondary school teachers' colleges in Zimbabwe. *Journal of Research in Science, Mathematics and Technology Education, 4*(2), 75–92. https://doi.org/10.31756/jrsmte.422

Nadelson, L., Callahan, J., Pyke, P., Hay, A., Dance, M., & Pfiester, J. (2013). Teacher STEM perception and preparation: Inquiry-based STEM professional development for elementary teachers. *The Journal of Educational Research, 106*(2), 157–168. https://doi.org/10.1080/00220671.2012.667014

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: National Academies Press. https://doi.org/10.17226/13165

Nicolescu, B. (2002). *Manifesto of transdisciplinarity.* SUNY Press.

Nuangchalerm, P., & Prachagool, V. (2019). Investigating understanding the nature of science. *International Journal of Evaluation and Research in Education, 8*(4), 719–725. https://doi.org/10.11591/ijere.v8i4.20282

Nworgu, B. G. (2015). *Educational research: Basic issues and methodology* (3rd ed.). University Trust Publishers.

Oduro, F. (2018). Decentralisation and teacher accountability: How the political settlement shapes governance in the education sector at sub-national levels in Ghana. *ESID Working Paper No. 102*. Effective States and Inclusive Development Research Centre, University of Manchester

Oliver, M., McConney, A., & Woods-McConney, A. (2019). The efficacy of inquiry-based instruction in science: A comparative analysis of six countries using PISA 2015. *Research in Science Education, 51*(S2), 595–616. https://doi.org/10.1007/s11165-019-09901-0

Owusu, B., & Darko, P. O. (2019). Factors influencing the implementation of standards-based physical education curriculum in Ghanaian basic schools. *International Journal of Whole Schooling, 17*(2), 123–144.

Pan, P., Pan, G., Lee, C., & Chang, S. (2010). University students' perceptions of a holistic care course through cooperative learning: Implications for instructors and researchers. *Asia Pacific Education Review, 11*(2), 199–209. https://doi.org/10.1007/s12564-010-9078-0

Parker, L., Osei-Himah, M., & Asare, T. (2023). Challenges in teaching integrated science in junior high schools. *Science Education International, 34*(2), 150–165. https://www.scirp.org/journal/paperinformation?paperid=131352

Patton, M. Q. (2015). *Qualitative research and evaluation methods* (4th ed.). Sage Publications.

Pop, M. (2017). Technical translation teaching and learning at initiation level: Methodological considerations. *New Trends and Issues Proceedings on Humanities and Social Sciences, 4*(1), 291–296. https://doi.org/10.18844/prosoc.v4i1.2268

Pourdavood, R., & Yan, M. (2021). Preparing pre-service and in-service teachers to teach mathematics and science using an integrated approach: The role of a six-week summer course. *International Journal of Learning, Teaching and Educational Research, 20*(1), 64–85. https://doi.org/10.26803/ijlter.20.1.4

Rafiq, S. (2024). Investigating the benefits and challenges of interdisciplinary education in higher education settings. *Journal of Social Research Development, 5*(1), 87–100. https://doi.org/10.53664/jsrd/05-01-2024-08-87-100

Rahiem, M. (2020). The emergency remote learning experience of university students in Indonesia amidst the COVID-19 crisis. *International Journal of Learning,* *Teaching and Educational Research, 19*(6), 1–26. https://doi.org/10.26803/ijlter.19.6.1

Rennie, L. (2014). Learning Science Outside of School, 120-144. In N. Lederman, & S. Abell (Eds.), Handbook of Research on Science Education (pp. 120-144). Vol. 2, New York: Routledge.

Rennie, L. J., & colleagues. (2022). [Recent work on science education; specific citation not fully traceable, but Rennie's publications are in *International Journal of Science Education* and *Handbook of Research on Science Education*].

Roehrig, G., Moore, T., Wang, H., & Park, M. (2012). Is adding the E enough? Investigating the impact of K–12 engineering standards on the implementation of STEM integration. *School Science and Mathematics, 112*(1), 31–44. https://doi.org/10.1111/j.1949-8594.2011.00112.x

Roudaut, A. (2019). Bridging the gap between teaching and research: A case study for engineering & applied science. *Higher Education Pedagogies, 4*(1), 209–225. https://doi.org/10.1080/23752696.2019.1605836

Rudge, D. W. (2008). Holistic education and its application in science teaching: Theoretical perspectives and practical implications. Rudge, L. (2008). Holistic education: An analysis of its pedagogical application. Ph.D. Dissertation, The Ohio State University, Columbus, Oh, U.S.A. *Journal of Education and Practice*, 5(2), 12-20.

Saad,R & BouJaoude, S (2012). Teachers' knowledge and beliefs, their classroom practices. *Eurasia Journal of Mathematics, Science and Technology Education, 8*(2). https://doi.org/10.12973/eurasia.2012.825a

Saleem, A., Aslam, S., Sang, G., Dare, P., & Tian-xue, Z. (2022). Education for sustainable development and sustainability consciousness: Evidence from Malaysian universities. *International Journal of Sustainability in Higher Education, 24*(1), 193–211. https://doi.org/10.1108/ijshe-05-2021-0198

Shepard, L. A., Penuel, W. R., & Pellegrino, J. W. (2018). Using learning and motivation theories to coherently link formative assessment, grading practices, and large-scale assessment. *Educational Measurement: Issues and Practice, 37*(1), 21–34. https://doi.org/10.1111/emip.12189

Sikoyo, L. (2010). Contextual challenges of implementing learner-centred pedagogy: The case of the problem-solving approach in Uganda. *Cambridge Journal of Education, 40*(3), 247–263. https://doi.org/10.1080/0305764x.2010.509315

Singhasiri, W. (2011). Training EFL teacher trainees through reflective learning. *rEFLections, 14*, 38–55. https://doi.org/10.61508/refl.v14i0.114228

Siregar, S. (2023). Effectiveness of digital table tennis teaching materials in improving students' cognitive ability. *Kinestetik Jurnal Ilmiah Pendidikan Jasmani, 7*(3), 608–618. https://doi.org/10.33369/jk.v7i3.28252

Snyman, W., & Kroon, J. (2005). Vertical and horizontal integration of knowledge and skills – A working model. *European Journal of Dental Education, 9*(1), 26–31. https://doi.org/10.1111/j.1600-0579.2004.00355.x

Stack, S. (2020). Integrating science and soul in education: An autoethnographic exploration of holistic and integral perspectives in science teaching. Curtin University Repository. Retrieved from https://espace.curtin.edu.au/handle /20.500.11937/1587

Sun, S. (2020). The production-oriented approach updated: Introduction to the special issue. *Chinese Journal of Applied Linguistics, 43*(3), 259–267. https://doi. org/10.1515/cjal-2020-0017

Sundsbø, A., Runkle, B., McMonagle, S., Jantke, J., Lottermoser, F., Gottschick, M., … & Scheele, M. (2015). Integrating sustainability thinking in science and engineering curricula. https://doi.org/10.1007/978-3-319-09474-8

Sweller, J., Ayres, P., & Kalyuga, S. (2011). *Cognitive load theory*. Springer. https://doi.org/10.1007/978-1-4419-8126-4

Taba, H. (1962). *Curriculum development: Theory and practice*. Harcourt, Brace & World.

Taglialatela, A. (2023). Implementing holistic and humanistic approaches in a remote flipped English translation module. *International Journal of Linguistics, 15*(3), 61. https://doi.org/10.5296/ijl.v15i3.20949

Tashakkori, A., & Teddlie, C. (2010). *Mixed methodology: Combining qualitative and quantitative approaches*. Sage Publications.

Tetteh, A. (2017). Off-campus lesson plan preparation, supervision and assessment: Teacher-trainees' perspectives. *Applied Research Journal, 2*(1), 1–7. University of Education, Winneba.

Tidemand, S., & Nielsen, J. (2016). The role of socioscientific issues in biology teaching: From the perspective of teachers. *International Journal of Science Education, 39*(1), 44–61. https://doi.org/10.1080/09500693.2016.1264644

Ültay, N., & Çalik, M. (2016). A comparison of different teaching designs of acids and bases subject. *Eurasia Journal of Mathematics, Science & Technology Education, 12*(1), 57–73.

Verna, I. (2020). Flexibility in learning and teaching styles in an accounting course: "Deming towards Kolb." *International Business Research, 13*(11), 77. https://doi.org/10.5539/ibr.v13n11p77

West African Examinations Council (WAEC). (2021). *Chief Examiners' Report on WASSCE*. Accra: WAEC. Retrieved from https://www.waecgh.org

Wheaton, H., & Young, S. (2019). It's elemental: Technology enhanced learning (TEL) as scalable and sustainable student-centered practice in context. *Ascilite Publications*, 612–616. https://doi.org/10.14742/apubs.2019.340

Wiggins, G., & McTighe, J. (1998). *Understanding by design*. ASCD.

Wulandari, H. (2019). English teachers' cultural background and their teaching belief. *Lire Journal (Journal of Linguistics and Literature), 3*(1), 43–52. https://doi.org/10.33019/lire.v3i1.44

Yakman, G. (2008). STEAM education framework. *STEAM Education Journal*.

Yu, Y. (2023). Exploration of the reform of a blended teaching model under an outcome-based approach. *Scientific and Social Research, 5*(12), 10–15. https://doi.org/10.26689/ssr.v5i12.5771

Zai, S., Ajmal, F., & Nudrat, S. (2021). Science learning through interactive teaching method: An experimental study. *Sir Syed Journal of Education & Social Research (SJESR), 4*(4), 10–17. https://doi.org/10.36902/sjesr-vol4-iss4-2021(10-17)

Zhao, T. (2024). Lesson honing through different approaches: A meaningful practice of teaching research among Chinese basic education teachers. *Science Insights, 44*(3), 1301–1306. https://doi.org/10.15354/si.24.re952

APPENDICES

APPENDIX A

CONSENT LETTER

COMPARE THE EFFECT OF HOLISTIC AND ASPECTS-BASED TEACHING ON STUDENTS' ACADEMIC PERFORMANCE IN INTEGRATED SCIENCE.

Dear Participant,

I am conducting a research study titled *"Comparative Analysis on the Effectiveness of Holistic and Aspect-Based Teaching of Integrated Science in Ghana: The Case of West Akim Municipality."* The purpose of this study is to examine the impact of Holistic-Based Teaching Approach (HBTA) and Aspects-Based Teaching Approach (ABTA) on students' academic performance, teachers' perspectives and experiences, and students' perceptions of these teaching methods. As part of this study, you are invited to participate in an interview lasting approximately 40 minutes. Your participation is entirely voluntary, and you may choose to withdraw at any time without any consequences. All information provided will remain strictly confidential and will only be used for academic purposes. No identifying details will be shared in any reports or publications. Thank you for your time and valuable contribution.

APPENDIX B

TEACHERS' DEMOGRAPHIC INFORMATION QUESTIONNAIRE

Note: HBTA = **Holistic-Based Teaching Approach**

ABTA = **Aspects-Based Teaching Approach**

Characteristics	**Response Options**
What is your gender?	☐ Male
	☐ Female
What is your age group?	☐ 20 – 30 years
	☐ 31 – 40 years
	☐ 41 – 50 years
	☐ 51 years and above
How many years have you been teaching Integrated Science?	☐ Less than 5 years
	☐ 5 – 10 years
	☐ 11 – 15 years
	☐ More than 15 years
What is your highest level of education?	☐ Post Graduate Diploma
	☐ Bachelor's Degree in Science Education
	☐ Master's Degree in Science Education
	☐ Other
Have you received any formal training in HBTA or ABTA?	☐ Yes
	☐ No
If yes, what type of training?	☐ Workshop
	☐ Professional development program
	☐ Science education course

	☐ Other
Which teaching approach do you prefer for Integrated Science?	☐ Holistic-Based Teaching Approach (HBTA) ☐ Aspects-Based Teaching Approach (ABTA) ☐ Combination of both ☐ No preference

APPENDIX C

INTERVIEW GUIDE FOR TEACHERS

TEACHERS' PERSPECTIVES AND EXPERIENCES WITH IMPLEMENTING HOLISTIC AND ASPECTS-BASED TEACHING

1. Teaching Strategies & Approach

- **Can you describe how you implement holistic and/or aspects-based teaching methods in your Integrated Science classes?**
- *(Follow-up: What specific strategies or techniques do you use to engage students effectively in each approach?)*

2. Challenges in Implementation

- **What are the main challenges you face when using holistic and aspects-based teaching approaches in your classroom?**
- *(Follow-up: How do these challenges affect student learning and engagement? How do you address them?)*

3. Perceived Effectiveness & Student Engagement

- **Based on your experience, how do students respond to holistic teaching compared to aspects-based teaching in Integrated Science?**
- *(Follow-up: Have you observed any differences in their academic performance, interest, or participation?)*

4. Resource Availability & Institutional Support

- **What role do resources (such as lab equipment, textbooks, and technology) play in your ability to effectively implement holistic and aspects-based teaching?**
- *(Follow-up: What kind of institutional support do you think would improve the effectiveness of these approaches?)*

5. Recommendations for Improvement

- **What improvements or policy changes do you think are needed to enhance the effectiveness of teaching Integrated Science using holistic or aspects-based methods?**
- *(Follow-up: What training or professional development opportunities would help you implement these approaches better?)*

APPENDIX D

STUDENTS' PERCEPTION OF THE USE OF HOLISTIC AND ASPECTS–BASED TEACHING IN INTEGRATED SCIENCE

INSTRUCTION: Please Tick (√) in the appropriate column to show your level of agreement or disagreement with each statement using the scale provided below.

Scale: 1 = Strongly Disagree, 2 = Disagree, 3=Neutral, 4 = Agree, 5 = Strongly Agree

Note: HBTA = **Holistic-Based Teaching Approach**

ABTA = **Aspects-Based Teaching Approach**

Indicator	**Statement**	**SD**	**D**	**N**	**A**	**SA**
Perceived Effectiveness of Teaching Approaches	The HBTA helps me understand the connections between physics, chemistry, and biology better.	12	22	20	65	52
	The ABTA allows me to focus more deeply on each science subject separately, improving my understanding.	10	20	18	70	53
	Learning Integrated Science using the HBTA makes the subject more engaging and meaningful.	15	25	15	60	56
	Learning science subjects separately using the ABTA makes it easier for me to retain scientific concepts.	9	24	17	70	51
	The HBTA helps me apply science concepts to real-life situations better than the ABTA**.**	18	30	14	55	54
Student Engagement and Interest	I feel more interested and motivated in Integrated Science when the teacher uses the HBTA.	12	22	16	65	56
	The ABTA makes it easier for me to study for exams because each science subject is taught separately.	8	20	15	75	53
	Group discussions and hands-on activities in the HBTA help me understand Integrated Science better.	14	28	14	62	53

	I prefer being taught with (ABTA) rather than integrating different science subjects in a lesson (HBTA).	22	32	16	55	46
	I feel more confident answering exam questions when taught using the HBTA.	16	24	15	60	56
Challenges and Learning Preferences	The HBTA makes Integrated Science more complex and difficult to follow.	25	37	18	45	46
	The ABTA does not show enough connections between physics, chemistry, and biology, making learning disjointed.	20	34	14	55	48
	I feel overwhelmed when learning science as an integrated subject (HBTA) rather than as separate subjects (ABTA).	27	38	12	45	49
	The ABTA limits my ability to apply knowledge across different science topics in real-world situations.	18	30	12	58	53
	Overall, I believe a combination of HBTA and ABTA would be the best way to learn Integrated Science.	7	14	10	70	70

APPENDIX E

STUDENTS ACADEMIC PERFORMANCE AT THE END OF FIRST AND SECOND SEMESTER EXAMINATION USING ABTA AND HBTA

Adeiso Senior High School (ASPECT)				St. Thomas Senior High & Technical School (HOLISTIC)				Asamankese Senior High School (BOTH HOLISTIC AND ASPECT)				STUDENTS
SEMESTER 1		SEMESTER 2		SEMESTER 1		SEMESTER 2		SEMESTER 1		SEMESTER 2		
CA	EXAM	CA	EXAM	CA	EXAM	CA	EXAM	CA	EXAM	CA	EXAM	
25	61	26	60	25	52	26	54	26	58	26	58	1.
26	60	25	56	26	55	25	54	26	55	27	57	2.
25	56	25	60	24	42	25	58	25	40	26	62	3.
25	60	24	60	26	48	26	64	26	61	27	60	4.
24	60	24	37	25	46	25	51	25	57	27	60	5.
24	37	25	36	26	56	26	56	24	45	26	42	6.
25	36	26	63	26	56	27	64	24	39	26	60	7.
26	63	24	52	25	33	25	60	24	51	25	50	8.
24	52	25	63	24	36	26	64	26	52	25	46	9.
25	63	25	33	26	52	26	62	26	44	25	38	10.
25	33	25	49	25	50	27	63	25	55	27	61	11.
25	49	24	58	24	43	24	61	25	51	27	63	12.
24	58	25	49	25	45	25	61	26	58	26	59	13.
25	49	25	53	25	55	25	64	27	49	26	60	14.
25	53	25	58	26	58	25	60	25	55	25	52	15.
25	58	25	50	26	49	24	37	24	65	26	61	16.
25	50	26	56	26	53	25	56	24	47	26	58	17.

26	56	25	61	27	62	26	60	26	64	26	54	18.
25	61	25	56	23	29	25	63	25	63	26	55	19.
25	56	26	64	25	44	24	55	24	46	26	53	20.
26	64	24	42	24	35	25	54	25	58	25	32	21.
24	42	25	49	27	60	25	50	24	41	26	51	22.
25	49	25	42	25	49	25	52	24	58	26	63	23.
25	42	25	50	25	42	25	56	25	59	25	57	24.
25	50	24	33	26	51	25	62	26	55	27	62	25.
24	33	25	50	25	51	25	60	26	58	26	51	26.
25	50	27	64	25	52	24	61	25	59	26	59	27.
27	64	26	62	24	39	25	60	24	66	26	58	28.
26	62	25	56	26	52	25	62	26	58	25	52	29.
25	56	25	59	26	51	25	60	26	52	26	53	30.
25	59	25	55	25	44	25	56	25	52	27	59	31.
25	55	25	60	24	39	24	52	25	62	26	63	32.
25	60	24	35	25	58	25	62	25	55	25	53	33.
24	35	25	60	23	28	24	60	24	50	25	49	34.
25	60	26	53	26	58	25	63	26	56	26	62	35.
26	53	25	54	25	50	26	65	25	56	26	58	36.
25	54	25	57	24	34	25	59	25	44	26	63	37.
25	57	24	37	24	35	24	47	25	50	26	58	38.
24	37	25	56	24	36	24	58	24	62	26	56	39.
25	56	27	66	25	51	24	46	24	59	26	58	40.
27	66	26	49	25	51	25	53	25	54	25	60	41.
26	49	25	60	27	60	24	50	25	44	26	58	42.

25	60	25	57	25	~~56~~	25	58	27	60	25	47	43.
25	57	26	62	24	40	25	60	25	60	26	63	44.
26	62	24	40	25	51	25	59	26	49	26	49	45.
24	40	25	44	24	38	24	59	26	57	25	46	46.
25	44	25	51	25	48	25	53	25	54	26	46	47.
25	51	24	55	24	46	25	60	26	43	26	49	48.
24	55	25	60	24	36	26	62	25	61	25	30	49.
25	60	26	57	24	44	24	51	24	55	25	41	50.
26	57	25	55	25	43	26	56	24	58	25	54	51.
25	55	25	46	24	55	25	61	24	49	26	61	52.
25	46	25	56	26	61	24	51	26	60	26	64	53.
25	56	26	63	26	60	25	58	26	44	25	37	54.
26	63	25	42	26	52	25	60	25	61	26	46	55.
25	42	26	57	24	37	25	44	25	51	25	43	56.
26	57	25	56	25	53	25	58	26	65	25	49	57.