UNIVERSITY OF ENERGY AND NATURAL RESOURCES, SUNYANI

DEPARTMENT OF GEOSPATIAL SCIENCES SCHOOL OF GEOSCIENCES

INTEGRATING GEOSPATIAL SCIENCE AND TECHNOLOGY IN GEOGRAPHY EDUCATION: PERCEPTIONS AND OPPORTUNITIES IN SENIOR HIGH SCHOOLS, GHANA

THOMAS ADONGO

UEMP2200223

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THOMAS ADONGO

UEMP2200223

MASTER OF PHILOSOPHY IN GEOINFORMATION SCIENCE

A DISSERTATION SUBMITTED TO THE DEPARTMENT OF GEOSPATIAL SCIENCES, SCHOOL OF GRADUATE STUDIES) IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF PHILOSOPHY IN GEOINFORMATION SCIENCE

NOVEMBER, 2025

DECLARATION AND CERTIFICATION

I, Thomas Adongo (UEMP2200223), hereby declare that, except for the references cited, which have been duly acknowledged, this submission is my own work towards a master's of Philosophy in GeoInformation Science, and that to the best of my knowledge, it contains no materials previously published by another person. I also declare that this has not been presented either in whole or in part for another degree in this University or elsewhere.

……………………….. ………………………..

Candidate's Signature: Date

Certified by

Major Supervisor: Surv. Ing. Lily Lisa Yevugah

Signature: .... Date:…..........................

Co-Supervisor: Mr. Louvis Boakye

Signature: .... Date: …..........................

Head of Department: Surv. Ing. Dr. Peter Damoah-Afari

Signature: .... Date: ....

ABSTRACT

This study establishes a baseline for integrating Geospatial Science and Technology (GST) in Ghanaian Senior High School Geography during the early rollout of the standards-based curriculum. Guided by TPACK/G-TPACK and TAM/UTAUT2, it examines current applications, teacher capacity, administrative support, student readiness and opportunities/constraints. A cross-sectional descriptive survey used stratified purposive and convenience sampling to collect questionnaires from students (*n* = 405), teachers (*n* = 25) and administrators (*n* = 15). Instrument quality was supported by expert review and internal consistency (Student Attitudes triad α = .79). Quantitative data were analysed in R (RStudio); open responses were thematically coded. GST use was limited and uneven (55.8% no prior exposure; 44.2% mainly via web mapping), yet awareness was high (74.3%) and support was strong (99%; 72.8% for immediate implementation). Teachers reported moderate familiarity with uneven preparation; administrators unanimously endorsed GST but reported few current initiatives. Inferential results reinforced the pattern: awareness differed by gender (small–to–moderate), attitudes did not differ by gender, and attitudes differed by region (medium)—implicating facilitating conditions (training, infrastructure, timetable/assessment alignment) rather than inherent preferences. A curriculumaligned, phased web-GIS pathway is recommended, pairing short, in-class PD with minimal ICT provision and leadership monitoring. Given the non-probability design, findings support analytical generalisation to comparable SHS contexts.

DEDICATION

This thesis is dedicated to my family, whose affection, love, encouragement, and daily prayers sustained me throughout this journey. I owe special gratitude to my wife, Victoria; my children, Bridget, Declan, and Ursula; my parents, Atanga Francis and Azumah Gifty; and my siblings, Rose, Moses, Ishmael, and Benedict.

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LIST OF ACRONYMS

Acronym	Meaning
Admin	Administrator
ANOVA	Analysis of Variance
CK	Content Knowledge
ESRI	ESRI (formerly Environmental Systems Research Institute)
G-TPACK	Geospatial Technological Pedagogical Content Knowledge
GES	Ghana Education Service
GIS	Geographic Information Systems
GPS	Global Positioning System
GST	Geospatial Science and Technology
ICT	Information and Communication Technology
IT	Information Technology
MoE	Ministry of Education
NCS	National Curriculum Statement
NaCCA	National Council for Curriculum and Assessment
OSM	OpenStreetMap
PD	Professional Development
PK	Pedagogical Knowledge
QGIS	QGIS (formerly Quantum GIS)
RS	Remote Sensing
SAMR	Substitution–Augmentation–Modification–Redefinition
SDGs	Sustainable Development Goals

SHS	Senior High School
STEM	Science, Technology, Engineering, and Mathematics.
TAM	Technology Acceptance Model
TK	Technological Knowledge
TPACK	Technological Pedagogical Content Knowledge
UTAUT2	Unified Theory of Acceptance and Use of Technology 2

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Geographic Information Systems (GIS), remote sensing (RS), and Global Positioning Systems (GPS) generally constitute geospatial technology. Globally, these tools have become central to spatial data analysis and decision-making in geography (CascanteCampos, 2023; Kholoshyn et al., 2021). Geospatial science and technologies have the strong potential to improve spatial thinking, enhance problem-solving skills, and foster student engagement through the visualisation and analysis of real-world data among students in education, particularly Geography (Akşit, 2021; Felix et al., 2018; Gusen et al., 2017). Ivan and Kurniawan (2020), Mathews et al. (2023), and Rubino-Hare et al. (2024) further show that GST supports inquiry-based, problem-oriented learning as students investigate issues such as urban growth, deforestation, or climate impacts.

In the early 1990s, some countries in North America, Europe, and parts of Asia had already integrated geospatial technologies into the senior high school curriculum (Bednarza & Van Der Scheeb, 2006; Kholoshyn et al., 2021). The adoption of Geospatial Science and Technology in Africa has advanced relatively slowly (Hlatywayo & Manik, 2022; Mkhongi & Musakwa, 2020). In South Africa, GIS was phased in under the National Curriculum Statement between 2006 and 2008 and formally embedded in the early 2010s (Breetzke et al., 2011; Mkhongi & Musakwa, 2020). This notwithstanding, many countries across the African region remain at preparatory or early adoption stages (Hlatywayo & Manik, 2022; Mzuza & Van der Westhuizen, 2020). Beyond Africa, Datta and Mete (2024) argue that advancing digital literacy is pivotal to modernising education systems and achieving Sustainable Development Goals (SDGs); integrating digital tools improves learning outcomes and narrows socio-economic gaps.

In the developing-country context, GIS has begun to appear in senior secondary geography syllabi in Nigeria, Malawi, Lesotho, and Botswana (Mzuza & Van Der Westhuizen, 2019; Oluwagbohunmi, 2023).

In Ghana, Geospatial Science and Technology education at the tertiary level began in 1998 at Kwame Nkrumah University of Science and Technology (KNUST)'s Department of Geomatics Engineering, initially at the certificate, diploma, and undergraduate levels and later expanding into graduate programs (Acquah et al., 2017).

Recent years have seen broader GST offerings across Ghanaian universities.

At the senior high school (SHS) level, however, geography instruction has largely remained theoretical and textbook-centred with limited hands-on work over the years (Gyasi Mensah & Osman, 2022). While awareness of Information Technology (IT) has grown, access to basic hardware/software often constrains practice (Barfi et al., 2021). Calls for pedagogy that is more interactive and technology-enabled are therefore wellplaced (Opoku, 2019; Osborne et al., 2020). Empirical studies suggest that integrating GST enhances engagement and learning (Akşit, 2021; Cascante-campos et al., 2023; Law, 2022; Manakane et al., 2023). For example, rather than treating population distribution or land-use change abstractly, students can map these phenomena in GIS to understand spatial patterns and relationships. Asakeboba et al. (2018), in their Ghanaian case study (Wesley Girls' Senior High School SHS), reported substantial performance gains when technology was incorporated into instruction.

Mzuza and Van Der Westhuizen (2019), in their research conducted in the Southern African region, found out that tertiary students who do not have the basics of GIS from the senior high schools always struggle to cope in GIS class at the tertiary level, which leads to a dislike of the course. They argued further that if GIS was introduced to the student at the pre-tertiary level, they might not have found themselves struggling with it at the tertiary level, and their interest might have been much more. Early exposure at SHS can therefore bridge skills gaps and better prepare students for tertiary studies and employment (Acquah et al., 2017). It is predicted that GST knowledge will be essential to the extent that one will not be able to do any work without GST in the near future (Acquah et al., 2017; Mzuza & Van Der Westhuizen, 2019).

These findings aligned with what was recommended in Ghana by Akon-Yamga et al. (2024), that the STEM curriculum at pre-tertiary levels be aligned with tertiary education requirements and the broader national Science, Technology, and Innovation strategy, which would go a long way to prepare students for tertiary education and the industrial revolution.

This study was conceived before and fielded during the initial rollout of Ghana's standards-based SHS Geography curriculum that embeds a geospatial strand (Ministry of Education (MoE), 2024; NaCCA, 2023). It focuses on legacy cohorts (Forms 2–3) not covered by the new strand at the time of data collection, thereby providing a prerollout baseline to inform implementation. Although educational policy now specifies geospatial competencies at SHS, there is limited Ghana-specific empirical evidence on SHS-level perceptions, readiness, and enabling conditions for GST integration. Existing Ghana studies generally emphasise ICT integration or attitudes, and the few that emphasise GIS either surveyed teachers or students or both, but in just a district or one of the regions in Ghana (Antwi, 2018; Arkorful et al., 2021; Gyasi Mensah & Osman, 2022; Opoku et al., 2021), while Southern African work documents secondaryschool GIS mostly outside Ghana (Fleming & Evans, 2021; Hlatywayo & Manik, 2022; Mzuza & Van Der Westhuizen, 2019). No pre-rollout SHS baseline for Ghana was identified in the literature consulted. This study addresses that gap by surveying administrators, teachers, and Forms 2–3 geography students to establish readiness and opportunity conditions ahead of full implementation.

1.2 Problem Statement

Geographic Information Systems (GIS), remote sensing (RS), and Global Positioning Systems (GPS) are vital for spatial analysis and are increasingly integrated into school geography to strengthen spatial reasoning, critical thinking, and practical skills (Baker et al., 2015; Mašterová, 2023; Mathews et al., 2023; Rubino-Hare et al., 2024).

Although Ghana's educational policy now specifies geospatial competencies at the SHS level, classroom uptake of Geospatial Science and Technology (GST) remains at an early stage (Ministry of Education (MoE), 2024; NaCCA, 2023). Geography instruction is still largely theoretical and textbook-centred, with constrained teacher training and limited access to software, hardware, and digital data (Arkorful et al., 2021; Gyasi Mensah & Osman, 2022).

However, there is no specific empirical evidence on the perceptions, readiness levels, and school-level enabling conditions for GST integration among SHS Geography stakeholders—students, Geography teachers, and school administrators—in Ghana. Existing Ghanaian studies tend to focus on ICT integration more broadly or on GIS at the tertiary level, and where SHS Geography is considered, it is usually in a small number of schools and from the perspective of a single stakeholder group (Acquah et al., 2017; Antwi, 2018). As a result, there is no pre-rollout, multi-site baseline that connects what these stakeholder groups think and are ready to do with the practical opportunities and obstacles they face in their schools for integrating GST into SHS Geography.

This thesis, titled *"Integrating Geospatial Science and Technology in Geography Education: Perceptions and Opportunities in Senior High Schools, Ghana,"* addresses this gap by providing a pre-rollout baseline based on legacy cohorts (Forms 2–3) in selected SHSs. Using a cross-sectional descriptive survey, the study assesses current GST use, teacher proficiency and preparedness, administrative support, and students' awareness and interest to inform the phased implementation of GST integration at the SHS level.

1.3 Aim and Objectives

1.3.1 Aim

To assess stakeholders' perceptions and the opportunities for integrating geospatial science and technology into SHS Geography education.

1.3.2 Specific Objectives

1. Assess the current level of application of geospatial science and technologies in the geography curriculum within Ghanaian senior high schools.
2. Evaluate the proficiency and preparedness of geography teachers to effectively integrate geospatial technologies into their instructional methodologies.
3. Examine the perceptions and support of school administrators regarding the incorporation of geospatial technologies within the academic curriculum.
4. Determine the level of awareness, readiness, and interest exhibited by students concerning the utilisation of geospatial technologies in their geographical studies.

1.4 Research Question

1. To what extent are geospatial technologies currently being used in the teaching and learning of geography in senior high schools?
2. What knowledge, skills, and level of preparedness do geography teachers have for integrating geospatial technologies into classroom instruction?
3. How do school administrators perceive and support the integration of geospatial technologies into the geography curriculum?

4. What is the level of awareness, readiness, and interest of students in using geospatial technologies for learning geography?

1.5 Purpose of the Study

The purpose of this study is to support the implementation of Ghana's standards-based SHS Geography curriculum by generating a pre-rollout baseline of stakeholders' perceptions, readiness, and enabling conditions for integrating geospatial technology, GIS, remote sensing, and GPS into classroom practice (Ministry of Education (MoE), 2024; NaCCA, 2023). Building on evidence that geospatial tools enhance students' spatial reasoning, inquiry, engagement, and practical skills, the study documents the views of students, teachers, and administrators and maps concrete opportunities for adoption (Baker et al., 2015; Mašterová, 2023; Mathews et al., 2023; Rubino-Hare et al., 2024). Specifically, it assesses (i) awareness and training, (ii) access to software, hardware, and data, and (iii) institutional support at the school level, and it identifies near-term obstacles likely to constrain classroom use (Arkorful et al., 2021; Gyasi Mensah & Osman, 2022). To guide early implementation, the study outlines professional-development priorities, a minimum essential infrastructure, and practical steps for school-level planning aimed at realistic integration of geospatial technology in SHS Geography. Methodologically, the study adopts a cross-sectional descriptive survey using questionnaires administered to students, geography teachers, and school administrators in five purposively selected SHSs across three ecological belts, as detailed in Chapter Three.

1.6 Significance of the Problem

Integrating geospatial technologies (GST) makes abstract spatial concepts tangible, increases engagement, and elevates the relevance of SHS Geography within Ghana's education system. Consistent use cultivates 21st-century competencies in spatial analysis, data interpretation, and problem-solving, preparing learners for further study and careers in urban planning, environmental management, disaster risk reduction, and related fields. By analysing stakeholder perceptions and practical opportunities, this study generates evidence to guide curriculum implementation, resource allocation, and teacher professional development, promoting equitable access regardless of school location or resourcing. It also contributes to the developing-country literature on GST at foundational levels and offers practitioners concrete, low-cost pathways for classroom integration.

1.7 Scope and Limitation of the Study

1.7.1 Scope

The study focuses on selected Ghanaian senior high schools (SHSs) and three stakeholder groups': students, geography teachers, and school administrators. It examines stakeholders' perceptions of integrating geospatial technologies (GST: GIS, remote sensing, and GPS) and evaluates enabling conditions, including infrastructure, software/data access, teacher capacity, ICT/internet availability, and institutional support. Anticipated educational benefits (e.g., deeper conceptual understanding, spatial reasoning, data literacy, and problem-solving) are considered. Drawing on a cross-sectional questionnaire survey, the study proposes practical, low-cost recommendations for sustainable, school-level implementation.

1.7.2 Limitations

Access to some stakeholders (e.g., policy actors) was constrained. The cross-sectional design and limited timeframe precluded observation of longer-term outcomes of GST integration. Variation in respondents' prior exposure to geospatial tools may have influenced response quality and occasionally required brief clarification. Importantly, data were collected from legacy cohorts (Forms Two and Three) not yet taught under the new geospatial strand; findings therefore represent pre-rollout baseline conditions, not outcomes of the revised curriculum.

1.8 Organization of Study

This thesis is organised into five chapters. Chapter one presents the background, problem statement, purpose, aim, objectives, research questions, significance, scope, and limitations. Chapter Two reviews the relevant literature and outlines the conceptual framework guiding the study. The methodology, including research design, population and sample, tools, data gathering methods, and analysis methodologies, is covered in Chapter 3. The findings are reported in Chapter Four, together with a discussion of how they relate to the research questions and existing literature. The conclusions and useful suggestions are presented in Chapter 5, along with the consequences and future research areas.

CHAPTER TWO LITERATURE REVIEW

2.1 Extent of Review

This chapter adopts an integrative, narrative literature review, synthesising international, regional, and Ghanaian studies to establish a scholarly foundation for the study. It critically examines the global trends, regional experiences, and Ghanaian context of integrating Geospatial Science and Technology (GST) into geography education. The review also discusses the conceptual framework that informed the adoption of educational technology and how this influences teacher behaviour, curriculum design, and instructional practice, which has the potential to model the future of the 21st-century student.

2.2 Scope of Review

2.2.1 Global Trends and Integration

Geospatial science and technologies, Geographic Information Systems (GIS), remote sensing (RS), and Global Positioning Systems (GPS), have become prominent in education reforms worldwide. Their integration reflects a broader push to strengthen spatial thinking and prepare learners for technology-intensive careers. The diffusion of GIS in school curricula has been uneven but broadly follows identifiable stages: early implementation in North America (late 1970s to 1990s), expansion to Europe and Australia (1990s to early 2000s), adoption across Asia, Africa, and Latin America (2005 to 2012), and wider policy-level integration after 2012 (Jekel et al., 2015; Kholoshyn et al., 2021).

Despite advances in software and the increasing availability of spatial data, classroom uptake remains limited in many contexts due to infrastructure gaps, insufficient teacher preparation, and policy–practice misalignment (Fleischmann et al., 2020). For example, a statewide study in North Carolina (U.S.) reported substantial teacher awareness of GIS but low classroom use, linked to curricular gaps and inadequate training (Osborne et al., 2020).

South Africa offers an instructive case. Although GIS entered the high school curriculum over a decade ago, implementation is still constrained by access to software/hardware and limited teacher training (Hlatywayo & Manik, 2022; Mkhongi & Musakwa, 2020). Low-cost and open-source options, such as QGIS and OpenStreetMap (OSM), show promise for project-based learning and for making spatial concepts tangible (Fleming & Evans, 2021). Yet reliable hardware, internet, and data access remain uneven.

Comparable barriers appear elsewhere. In Croatia, over 77% of teachers reported not using GIS, citing lack of training, insufficient software/hardware, and limited curricular presence (Šiljeg et al., 2022). Studies from Hong Kong (Ching, 2023), Kenya (Wakhungu, 2023), and the Seychelles (Constance et al., 2018) similarly show that even where policy encourages integration, teacher readiness is the pivotal bottleneck. In Turkey (Salih Yildirim, 2021), GIS is formally in the curriculum, but many teachers persist with textbook-based methods;

targeted in-service professional development using a G-TPACK approach significantly improved confidence and classroom use.

International evidence points to a recurring pattern: policy inclusion and tool availability do not guarantee classroom integration without concurrent investments in teacher capacity, infrastructure, and locally workable resources (Fleischmann et al., 2020; Osborne et al., 2020). These lessons frame the need to establish a pre-rollout baseline of perceptions, readiness, and enabling conditions in Ghanaian senior high schools.

Globally, GST has moved from early pilots to wider curricular presence, yet actual classroom use still lags policy in many systems. The main bottlenecks remain teacher capacity, curriculum fit, and access to workable tools and data. Evidence from diverse regions shows that inclusion on paper does not guarantee routine classroom practice. This study adds a Ghana-specific, pre-rollout baseline that shows where SHS Geography currently sits on this global diffusion arc and which levers could accelerate adoption.

2.2.2 Pedagogical Benefits and Instructional Impact

From a pedagogical standpoint, integrating geospatial technologies in the classroom strengthens spatial reasoning, critical analysis, and engagement with authentic, realworld problems (Baker et al., 2015; Duarte et al., 2022; Law, 2022; Mathews et al., 2023; Rubino-Hare et al., 2024). A Ghanaian case study at Wesley Girls' Senior High School reported higher student performance and engagement when technologyintegrated pedagogy was used compared with traditional methods (Asakeboba et al., 2018). Experimental and quasi-experimental evidence further indicates that exposure to GIS concepts enhances students' spatial-thinking proficiency, a foundational competency for geography and STEM learning (Duarte et al., 2022).

Geospatial tools enable inquiry-driven, experiential learning and help shift instruction away from rote memorisation toward investigation and interpretation (Law, 2022).

Instructional impact is strongest when GST is embedded within a Technological Pedagogical Content Knowledge (TPACK) frame. In-service professional development grounded in G-TPACK produced marked gains in teachers' confidence and classroom use of GIS in Turkey (Salih Yildirim, 2021). Similarly, studies of prospective teachers show that aligning content, pedagogy, and technology builds readiness to use GIS effectively in instruction (Koyuncuoğlu & An, 2021).

Evidence from classroom cases, empirical studies, and teacher-education research suggests that GST can advance higher-order geographic learning when paired with targeted teacher preparation and coherent pedagogical design.

The literature consistently links GST to richer inquiry, stronger spatial reasoning, and more authentic assessment tasks. What is under-documented is how many of these benefits materialise in resource-constrained schools and under limited G-TPACK conditions. Few studies pair perceived usefulness with observed use in the same cohort. This study adds side-by-side evidence on perceived benefits and actual application in Ghanaian SHSs, clarifying where benefits are latent versus realised.

2.2.3 Teacher Capacity and Professional Development

Across contexts, teacher capacity is a primary bottleneck to effective GST integration. Reviews and empirical studies note persistent gaps in pedagogical and technical preparedness, even where tools and data are available (Mašterová, 2023; Osborne et al., 2020). Broader ICT/GIS reviews similarly emphasise that without sustained humancapacity development, classroom uptake remains limited (Kuria et al., 2019).

Even in developed settings, teacher awareness of GIS can be high while classroom use stays low due to curricular alignment issues and limited training (Osborne et al., 2020). In sub-Saharan Africa, scholarship calls for national strategies that pair curriculum reform with teacher capacity building; without scalable, accessible professional development, GST remains underutilized (Fleischmann et al., 2020). Empirical work in South Africa shows similar constraints, restricted software/hardware access, and insufficient training limit classroom implementation despite policy inclusion (Hlatywayo & Manik, 2022; Mkhongi & Musakwa, 2020).

Evidence points to practice-centered PD as the most effective lever. In-service training grounded in G-TPACK and using QGIS significantly improved teachers' confidence and classroom use of GIS in Turkey (Salih Yildirim, 2021). Pre-service work likewise shows that aligning content, pedagogy, and technology builds readiness to use GIS effectively (Koyuncuoğlu & An, 2021). Complementary studies demonstrate the feasibility of open-source ecosystems (e.g., QGIS and OpenStreetMap) to lower cost barriers and support project-based learning, provided schools can ensure basic hardware, internet, and data access (Fleming & Evans, 2021).

Teacher knowledge and confidence are the strongest predictors of meaningful GST integration, but many accounts infer capacity indirectly and treat PD generically. There is limited evidence on geospatial-specific competencies and on low-cost PD pathways that suit SHS constraints. The Ghanaian context especially lacks concrete indicators of teachers' readiness and timeframes for adoption. This study adds direct measures of teacher familiarity, prior coursework, confidence, and preferred timelines, interpreted through a TPACK/G-TPACK lens.

2.2.4 Ghanaian Context and Contribution

In Ghana, curriculum reforms acknowledge the importance of environmental systems and spatial cognition; the current standards-based SHS Geography curriculum embeds a strand on geospatial data collection, representation, and interpretation (Ministry of Education (MoE), 2024; NaCCA, 2023). Yet scholarly reviews note that geoscience/geospatial literacy has historically been underemphasized and unevenly implemented across the system (Sapah et al., 2023). These conditions set the context for measuring readiness during the curriculum's initial rollout.

Teacher capacity remains a pivotal constraint. Using a TPACK lens in Ghanaian SHSs, Mensah et al. (2022) found strong content/pedagogical confidence but comparatively weak technological knowledge, especially for GIS and low levels of classroom use. Broader Ghana studies similarly report willingness to use ICT but limited access, training, and institutional support (Arkorful et al., 2021; Gyasi Mensah & Osman, 2022). From the learner side, students value geography but often struggle to connect abstract topics to real-world contexts without interactive tools (Ntim et al., 2020; Opoku et al., 2021). Together, these findings point to the need for practice-centred PD, access to software/hardware/data, and school-level support to translate policy into pedagogy (Mensah et al., 2022).

The consolidation of GST capacity at the tertiary level is generating labour-market pull and justifying SHS preparedness. From BSc to MSc/MPhil, the University of Mines and Technology (UMaT) offers Geomatics/Geomatics Engineering (*University of Mines and Technology (UMaT), Tarkwa*, 2024). There is an MSc GeoInformation Science programme at the University of Ghana (University of Ghana, 2016). The University of Ghana offers RS/GIS instruction through the RS-GIS. Through diploma, bachelor's, and postgraduate programs, the Department of Geospatial Sciences at UENR teaches GIS, remote sensing, GNSS/photogrammetry, and related geospatial techniques (*Academic*

Departments and Programmes – University of Energy and Natural Resources – Sunyani, 2025). A BSc and an MPhil in geospatial science are available from UBIDS (SDD-UBIDS) Admissions, 2025. The need for spatial abilities is highlighted by this tertiary provision, which also supports the need for earlier exposure at SHS.

Contribution of the present study: situated prior to and during the initial rollout of Ghana's standards-based SHS Geography curriculum, this study focuses on legacy cohorts (Forms 2–3) not yet taught under the geospatial strand. It delivers a pre-rollout baseline of perceptions, readiness, and enabling conditions across students, teachers, and administrators and translates findings into actionable recommendations for PD priorities, minimum-viable toolkits, and school-level planning to support early, realistic GST integration in SHS (NaCCA, 2023).

Policy interest in digital and geospatial skills is visible in Ghana, but empirical schoollevel integration is uneven and sparsely documented. These aims are consistent with Ghana's Education Strategic Plan 2018–2030 (Ministry of Education, 2018). Prior Ghana studies often focus on ICT broadly rather than GST specifically, and usually at a small scale. There is a need for a national-level snapshot that includes multiple stakeholder groups. This study adds a multi-site, multi-stakeholder baseline across SHSs, specifying adoption conditions unique to the Ghanaian curriculum and infrastructure landscape.

2.2.5 Previous Studies on Geography Education in Ghana

The curriculum established by the Ghana Education Service emphasises the importance of geographical literacy and ecological stewardship; however, it is deficient in explicit directives regarding the implementation of Geospatial Science and Technology (GST) (Sapah et al., 2023). This deficiency highlights a more significant disconnection between educational policy frameworks and contemporary technological advancements in geography education. Antwi (2018) highlighted the pronounced disparities in access to Information and Communication Technology (ICT) between urban and rural educational institutions. This significant obstacle jeopardises the nationwide integration of Geographic Information Systems (GIS) in pedagogy.

Existing Ghana studies highlight curricular aspirations and ICT disparities but provide limited quantitative evidence on GST awareness, readiness, and barriers in SHS Geography. Much of the work is descriptive or single-site, making it hard to generalize. There is also little triangulation across students, teachers, and administrators. This study adds broad, comparable indicators across all three groups, enabling clearer generalisations about where integration stands now.

2.2.6 Perceptions of Teachers and Students

Both educators and learners exhibit favourable attitudes towards the prospects of technology-enhanced geography education. Arkorful et al. (2021) reported a substantial level of receptiveness among teachers towards digital instruments; however, they emphasised that inadequate training in GIS constitutes a significant impediment. Mensah et al. (2022) advocate for the alignment of in-service training initiatives with the Technological Pedagogical Content Knowledge (TPACK) framework, incorporating experiential learning with geospatial technologies. Students also display a positive disposition towards GST. As noted by Opoku (2019), learners express a desire for more interactive and visually stimulating instructional sessions, particularly in domains such as cartographic interpretation and environmental transformation. Ntim et al. (2020) corroborate that instruction augmented by technology not only enhances understanding but also fosters greater enthusiasm for the discipline.

Teachers and students often express positive attitudes toward GST, yet enthusiasm does not always translate into classroom use without training and support. Cross-group comparisons by region, gender, or prior exposure are scarce in Ghanaian SHSs. We also lack evidence connecting attitudes to concrete intentions under constraints. This study incorporates large-sample indicators of attitudes, readiness, and intention, enabling straightforward inferential contrasts to inform targeted interventions.

2.2.7 Infrastructure and Access Challenges

Infrastructure remains the biggest barrier to adopting GST in the Ghanaian educational system. Antwi (2018) noted that many schools lack even basic computer laboratory facilities. When such laboratories are available, they are often underused due to internet connectivity issues or the lack of licensed software. A similar study shows that in South Africa, only well-funded institutions can afford the necessary equipment and training needed for effective GIS teaching (Breetzke et al., 2011; Fleischmann et al., 2020). Ghanaian schools, particularly in rural areas, need targeted investments to close this digital gap.

Infrastructure and connectivity remain the dominant barriers across Africa, and Ghana is no exception. Prior studies list constraints but rarely prioritise which ones most strongly block adoption at the school level. Moreover, infrastructure discussions seldom connect to quick wins like web-GIS that can start integration early. This study adds a ranked view of barriers/enablers from multiple stakeholders and identifies pragmatic near-term routes (Web GIS) while longer-term infrastructure improves.

2.2.8 Conceptual Framework

This study adopts a conceptual framework that explains how interacting technological, pedagogical, institutional, and learner factors shape the integration of Geospatial Science and Technology (GST) in Senior High School (SHS) geography. It draws on the

Technological Pedagogical Content Knowledge (TPACK) model (Felix et al., 2018; Mishra & Koehler, 2006). Its geospatial extension, the Geospatial TPACK (G-TPACK) framework (Akşit, 2021; Salih Yildirim, 2021), as well as the Technology Acceptance Model (TAM) (Firomumwe & Gamira, 2021; Masrom, 2007), originally modelled in 1989, and its extended form, UTAUT2 (Raman & Don, 2013). Together, these theories explain how teachers' competence, students' perceptions, and contextual enablers determine the adoption of GST in educational settings.

2.2.8.1 Theoretical Foundations

According to TPACK, effective technology integration depends on the dynamic intersection of content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK). Within SHS Geography, this means teachers must skillfully combine disciplinary content (e.g., land use, population, or climate) with pedagogical strategies and technological tools such as ICT tools. The G-TPACK perspective expands this to emphasise spatial reasoning, map-based inquiry, and visualisation, positioning GST as both a technological and cognitive domain. In parallel, TAM and UTAUT2 explain user acceptance through perceived usefulness, ease of use, facilitating conditions, and behavioural intention. In this study, these models clarify why teachers and students may hold positive attitudes toward GST: even when access and training are limited, perceived educational benefits often outweigh technological barriers. Administrators' support serves as a facilitating condition that strengthens actual use.

2.2.8.2 Framework Constructs

The framework links four core constructs aligned with the study's specific objectives:

1. Current Application (OBJ1): the extent, frequency, and forms of GST use in SHS Geography classrooms, representing observed adoption behaviour.

2. Teacher Capacity (OBJ2): Teachers' GST knowledge, skills, confidence, and professional development relevant to integrating GST into SHS Geography.
3. Administrative Support (OBJ3): Leadership perceptions, infrastructure provision, and institutional culture that serve as facilitating conditions within UTAUT2.
4. Student Readiness (OBJ4): Students' awareness, motivation, and perceived usefulness of GST tools, representing behavioural intention to learn and apply them (TAM)

These constructs interact to produce a synthesised "Opportunities and Barriers" construct, represented in the central node. This central node captures policy alignment, tertiary partnerships, the balance between GST tools and hardware/connectivity/data constraints, and funding. It is treated as a derived outcome construct, not as a separate empirical objective.

2.2.8.3 Integration Logic

The framework posits that the likelihood of GST integration increases when teachers possess adequate G-TPACK competence, administrators provide institutional and infrastructural support, and students perceive GST as useful, engaging, and relevant to their future learning and careers. These components interact dynamically: teacher capacity and administrative support enhance perceived usefulness and actual classroom use; student readiness reinforces policy commitment; and contextual opportunities reduce systemic barriers. This conceptual model aligns with the SAMR model (Wahyuni et al., 2020), emphasising that technology integration progresses from substitution toward redefinition of learning experiences.

Figure 2.1, therefore, represents a TPACK–TAM–UTAUT2–G-TPACK–informed systems model that situates GST adoption within Ghana's evolving standards-based geography curriculum.

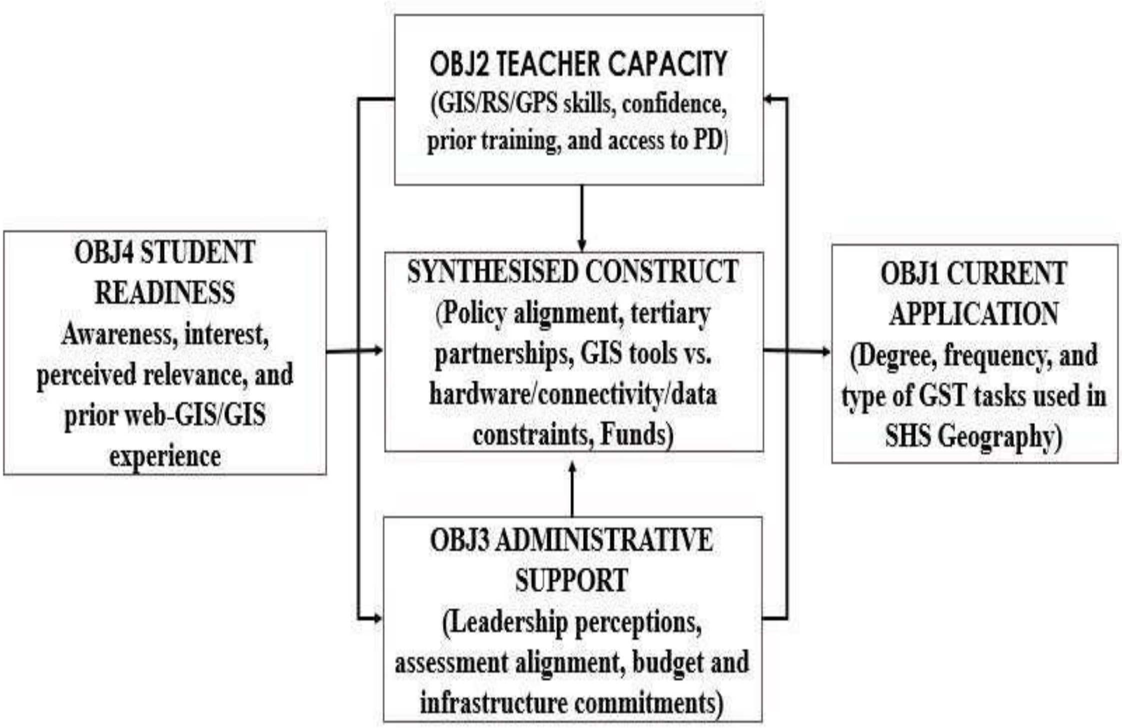

Figure 2. 1: Conceptual framework for GST integration in SHS Geography

Source: Author, based on the cited literature

The conceptual framework (Figure 2.1) synthesises insights from the TPACK, GTPACK, TAM, UTAUT2, and SAMR models to illustrate the interrelationships among key factors shaping the integration of Geospatial Science and Technology (GST) in Senior High School (SHS) Geography. At its core, the current application embodies the practical application of GST tools in teaching and learning. It is influenced directly by *teacher capacity* (skills, confidence, and professional development), *administrative support* (institutional leadership, timetable, and infrastructure alignment), and *student readiness* (awareness, motivation, and prior web-GIS exposure). These three elements interact dynamically, reinforcing or constraining one another. Overarching them are *opportunities and barriers*, which include policy alignment, tertiary partnerships, access to tools and data, connectivity, and funding, factors that can either enable or inhibit integration.

2.2.8.4 Construct Definitions

The current application denotes the degree, frequency, and type of GST tasks used in SHS Geography. *Teacher capacity* covers GIS/RS/GPS skills, confidence, and access to PD (TPACK/G-TPACK orientation). *Administrative support* reflects leadership perceptions, timetable/assessment alignment, and budget/infrastructure commitments. *Student readiness* comprises awareness, interest, perceived relevance, and prior webGIS experience. Synthesised Opportunities and Barriers capture policy alignment, partnerships, and open tools versus hardware/connectivity/data constraints.

2.3 Relevance of the Literature Review

The review explains why, in spite of global recognition of GST and policy momentum, GST integration in Ghanaian SHS geography lags. Evidence shows uptake depends less on tools than on teacher capacity, leadership, and minimum infrastructure (Fleischmann et al., 2020; Osborne et al., 2020). Ghana studies report strong pedagogy but weak GISspecific skills and resource constraints that slow classroom use (Arkorful et al., 2021). International work indicates that inquiry-driven tasks and basic web-GIS exposure boost engagement (Duarte et al., 2022; Manakane et al., 2023). These findings ground the study's framework current application, teacher capacity, administrative support, student readiness, and contextual enablers/barriers, and guide instrument design and school-level sampling (Hlatywayo & Manik, 2022; Mkhongi & Musakwa, 2020;

Fleming & Evans, 2021).

CHAPTER THREE MATERIALS AND METHODS

3.1 Study Area

3.1.1 Location and Extent

Ghana, in West Africa, covers approximately 238,533 km² (about 92,000 mi²) and is characterised by coastal plains along the Gulf of Guinea, tropical forests, and northern savannahs. It shares borders with Côte d'Ivoire (West), Burkina Faso (North), and Togo (East), with the Gulf of Guinea to the south (Sapah et al., 2023; World Bank, 2021).

Figure 3.1 shows the study area.

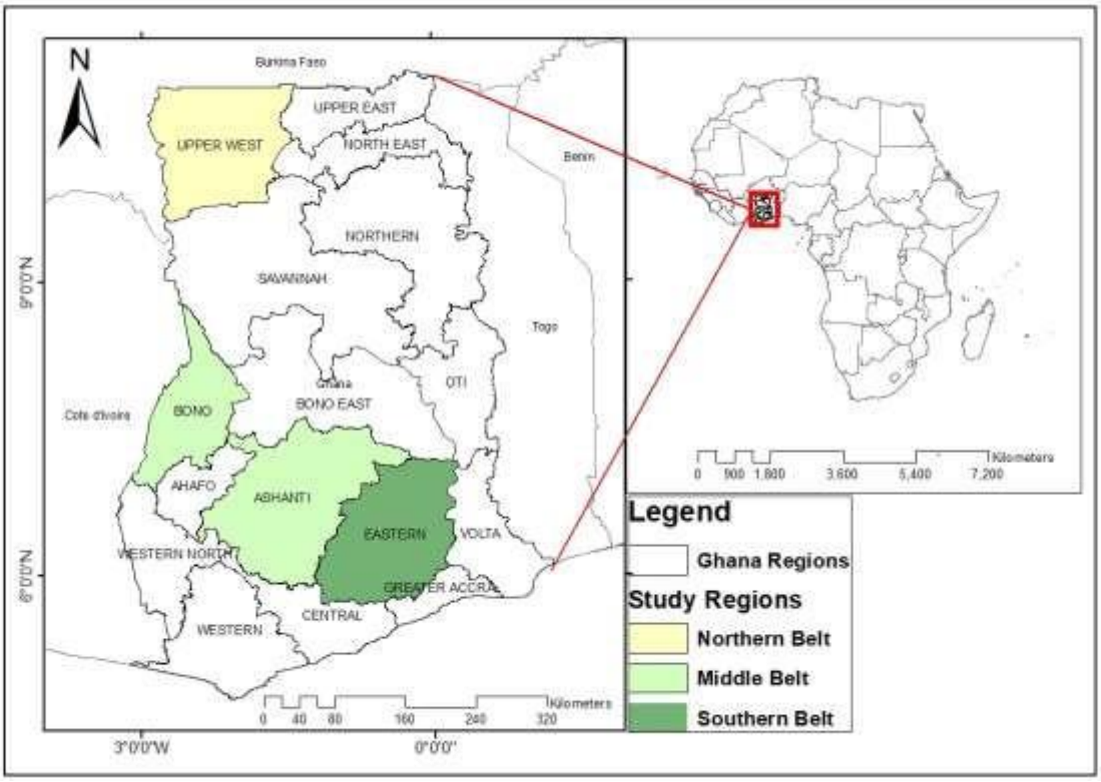

Figure 3. 1: Study Area

Ghana is retained as the national study area; however, a stratified, purposive sample of five SHSs across ecological belts and urban–rural areas was employed to capture key variation efficiently (NaCCA, 2023). Within these sites, a cross-sectional, multistakeholder survey of students, geography teachers, and school administrators provided triangulated evidence on perceptions, readiness, and enabling conditions. This fiveschool, multi-stakeholder design is feasible within time, access, and resource limits and supports analytical generalisation to comparable SHS settings.

3.1.2 Population

With a population of over 31 million as of the 2020 census, Ghana boasts a diversified population. There are more than 100 ethnic groups that make up the population. The demographic distribution varies by region, with the Upper West Region having the least population and urban areas like Accra having the most (Ghana Statistical Service, 2021). This diversity influences social changes and educational needs within the country.

3.1.3 Occupation

The economy of Ghana is basically based on farming, which employs a significant portion of the country's total population. Key agricultural products include cocoa, cashew, cassava, yam, and maize, while mining, manufacturing, and services also make important contributions to livelihoods and national income (Ministry of Food and Agriculture, 2021). The occupational landscape reflects the educational background of the population, with many individuals engaging in informal employment due to limited access to formal education and training opportunities.

3.1.4 Educational Landscape

There are 699 public Senior High Schools (SHS) and 212 public Technical and Vocational Education and Training (TVET) institutes in Ghana, spread across its sixteen regions (Ministry of Education, 2023). The regions include Greater Accra, Western North, Bono, Bono East, Ashanti, Western, Eastern, Northern, Central, and Ahafo. The administrative districts and municipalities within these regions are responsible for local governance, implementing educational policies, and resource allocations. Ghana's education system has expanded access while pursuing quality reforms over the past decade, guided by the Ministry of Education's Education Strategic Plan. Policies and targeted investments, especially at the senior high school level, have supported school construction and rehabilitation, teacher development, and ICT-supported learning, improving progression into Senior High School (SHS). Despite these gains, persistent constraints remain, including uneven teacher deployment, inadequate learning resources, and pronounced urban–rural disparities in infrastructure and learning conditions. Within SHS, curriculum updates position the phase to prepare learners for both further study and work, with the revised standards-based geography curriculum. The new curriculum emphasises 21st-century skills explicitly. It makes room for geospatial competencies (e.g., geospatial data collection, representation, and interpretation). These conditions create a relevant backdrop for this study: technology access, teacher capacity, leadership support, and infrastructure are unevenly distributed across districts, shaping the feasibility and pace of integrating geospatial technology in

SHS classrooms.

3.2. Material Description

The following materials and software were used for this study. Table 3.1 shows the list of software and materials used for the study.

Table 3. 1: List of Software and Materials Used for the Study

Software-	Purpose of Usage
R Studio	For Statistical Analysis, data cleaning, data processing and Visualizations.
Kobo Collect	For Data Collection
ArcGIS 10.8	For Data Process and Visualisation
Ghana Shape files	Preparation of the study area Map

3.3 Methodology

3.3.1 Flow Chart

Figure 3.2 shows the sequence and method employed in embarking on the research.

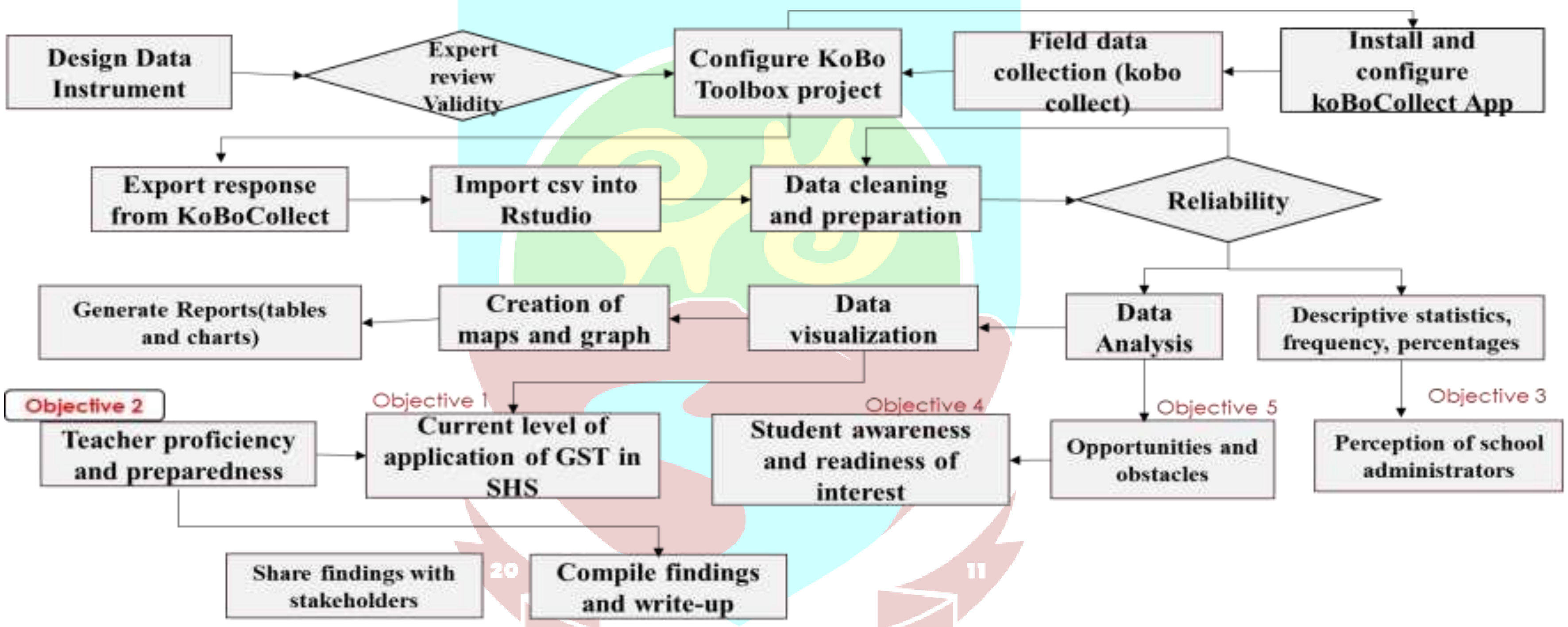

Figure 3. 2: Flow Chart of Methodology

3.3.2 Research Design

The study adopted a predominantly quantitative, cross-sectional survey design, complemented by qualitative data from open-ended items. This design made it possible to describe, at a single point in time, the perceptions, readiness, and enabling conditions for integrating geospatial science and technology (GST) in senior high school geography. Structured questionnaires were used to collect numerical data under four sections:

(a) Demographic information

(b) Awareness and experience with GST

(c) Perceptions of GST

(d) Additional open-ended comments.

A small pilot test with 15 respondents (5 students, 5 teachers, and 5 administrators) was conducted with participants from schools outside the main sample to check clarity, timing, and item wording. Feedback from the pilot led to minor wording and sequencing adjustments to improve comprehension. Although the pilot helped refine the instrument, internal consistency (Cronbach's α) and other reliability diagnostics were computed using the full study dataset, while responses to open-ended items were summarised qualitatively to complement the quantitative findings.

3.3.3 Population and Sample Size

3.3.3.1 Population

The target population for the study includes senior high school geography teachers, geography students, and school administrators in Ghana. Specifically, the study focuses on senior high schools in the Bono, Eastern, Upper West, and Ashanti Regions of

Ghana.

3.3.3.2 Sample Size

The research employed a non-probability sampling approach that combined stratified, purposive, and convenience sampling methods. A stratified purposive design was applied: Ghana was partitioned into three belts (northern, middle, and southern) using administrative/ecological considerations. Within each stratum, Senior High Schools (SHSs) were purposively selected to capture variation in urban–rural context, infrastructure, and ICT/GST readiness. The achieved sites were Upper West (Lawra SHS) for the northern belt; Bono (Odomaseman SHS, Seikwa SHS) and Ashanti (Prempeh SHS) for the middle belt; and Eastern (Kade SHS) for the southern belt. Within the selected schools, teachers and administrators were purposively sampled due to their roles in instruction, resource allocation, and oversight. The targeted teachers included only the geography teacher, while the school administrators included heads, assistant heads, housemasters/housemistresses, senior form masters/mistresses, and department heads. Students were recruited by convenience sampling from intact Form Two and Form Three geography classes. They were deliberately chosen because the 2024/2025 standards-based curriculum was introduced to Form One students only, allowing this study to capture pre-rollout baseline conditions.

Table 3.2 below shows the respondents to the three questionnaires deployed.

Table 3. 2: Shows the Distribution of Sample Size

GROUP	FREQUENCY	PERCENTAGE (%)
STUDENTS	405	91.0
TEACHERS	25	5.6
SCHOOL ADMINISTRATORS	15	3.4
TOTAL	**445**	**100**

This sample size was deemed sufficient for both descriptive and comparative analyses. The selected respondents are rich in information and offer relevant viewpoints to fulfil the study's aims. The sample sizes reported in Table 3.2 were determined pragmatically at the school level. For students, all Form Two and Form Three learners offering Geography in the four selected SHSs and present on the days of data collection were invited to participate, resulting in 405 valid student responses. For teachers, all Geography teachers in the selected schools (n = 25) were included. For administrators, heads, assistant heads, and Heads of Department responsible for Geography or curriculum in each school (n = 15) were targeted. In total, the study collected data from 445 participants.

This census-style approach within the selected schools was adopted because the number of potential respondents per school was relatively small and because the study aimed to obtain a comprehensive pre-rollout baseline rather than to estimate population parameters for inferential generalization.

3.4 Data Collection Methods

The study employed questionnaires as the only data collection method in this research. This method was chosen to gather both quantitative and qualitative data to support the research objectives.

3.4.1 Questionnaires

Questionnaires were administered to senior high school geography students, teachers, and school administrators. The questionnaire was structured to collect data on the level of awareness and usage of geospatial technology, perceptions of GST integration, and perceived challenges and benefits. The questionnaire included both closed-ended questions, using Likert scales, and open-ended questions, which allowed respondents to express their views more freely. The three questionnaires used in this study—one each for students, geography teachers, and school administrators—are reproduced in Appendices A, B, and C, respectively.

3.5 Reliability and Validity

3.5.1 Reliability

Multi-item Likert scales designed to evaluate the same construct were scrutinised for internal consistency. Specifically, the Student Attitudes to GST scale consisted of three 5-point items (Q12–Q14, coded from 1 to 5; devoid of reverse-keyed items). A composite score was derived as the mean of the available items, necessitating a minimum of two completed items. The assessment of reliability was conducted utilising Cronbach's alpha (α), the average inter-item correlation, item-total correlations, and the metric "alpha if item dropped." In accordance with recommendations for exploratory research, thresholds of $\alpha \geq 0.70$ and item-total correlations of $r \geq 0.30$ were regarded as acceptable. Indicators about administrators and teachers were represented as single items or heterogeneous constructs; thus, they were reported descriptively, without an analysis of internal consistency. For the Student Attitudes triad (Q12–Q14), **α = 0.79**, item total r = 0.56 - 0.70; alpha-if-item-dropped showed no improvement.

3.5.2 Validity

Content validity was addressed by ensuring that the item wording matched the construct of student attitudes regarding GST and by conducting an informal review with experts to evaluate clarity and relevance. Together, these steps resolved content validity concerns throughout the instrument's development. Since a dominant first eigenvalue suggests a single underlying factor, construct validity for the Student Attitudes scale was then assessed using (i) the inter-item correlation matrix and (ii) the eigenvalues of that matrix to assess unidimensionality. For validation, a simple one-factor exploratory analysis was used when appropriate. Measures with only one item were not subjected to factor analysis.

3.6 Ethical Considerations

Permission to conduct the research in selected schools was sought from and approved by the heads of participating institutions. Participation was entirely voluntary. Respondents were informed about the study's purpose, procedures, and potential risks, and provided informed consent (or assent where applicable). No identifying personal information was collected on questionnaires; responses were anonymized and stored on password-protected devices. Data were used solely for academic purposes and reported in aggregate form to ensure confidentiality and protect participants' privacy.

3.7 Data Analysis Techniques

The study employed both quantitative and qualitative data analysis techniques.

3.7.1 Quantitative data analysis

Questionnaire data were cleaned and analysed in R (RStudio). Descriptive statistics (frequencies, percentages, means, and standard deviations) summarised respondent profiles and item responses. Cross-tabulations explored relationships between categorical variables (for example, awareness by region or gender). Where informative, simple inferential checks, **Chi-square tests** for associations between categorical variables and **t-tests** or **one-way ANOVA** for comparisons of group means, were conducted in R using base functions and reported as exploratory rather than hypothesistesting results. Visualisations were produced using ggplot2 for charts and ArcGIS (ArcGIS Desktop) for spatial maps and spatially referenced summary charts. Typical R packages used included dplyr, tidyr, ggplot2, psych, and base stats.

3.7.2 Qualitative data analysis

Open-ended questionnaire responses (items soliciting challenges, recommendations, and illustrative experiences) were analysed using thematic analysis. The analytic steps were:

(i) familiarisation through repeated reading

(ii) open coding to identify salient ideas and phrases

(iii) grouping codes into higher-order themes that map onto the study's five constructs (current application, teacher capacity, administrative support, student readiness, and opportunities/barriers) and reviewing and refining themes for coherence.

Coding was undertaken manually with organisational support from R for text processing and tabulation where required. Some qualitative summaries that were spatially specific were linked to maps produced in ArcGIS to aid interpretation.

CHAPTER FOUR RESULTS AND DISCUSSION

4.1 Profile of Sampled Schools and Respondents

This subsection outlines the contextual background related to the educational institutions and respondents included in the study. The presentation of these characteristics offers essential context for interpreting the findings. There are variations in institutional resources and facilities, teacher qualifications, student demographics, and administrative perspectives. This may significantly influence the integration of Geospatial Science and Technology (GST) into the geography curriculum of the senior high school level.

4.1.1 Profile of Sampled Schools

Five senior high schools were purposively selected across four regions of Ghana to reflect geographical diversity and educational contexts. Lawra Senior High School (Upper West Region – northern belt). Odomaseman Senior High School (Bono Region – middle belt), Seikwa Senior High School (Bono Region – middle belt), Prempeh Senior High School (Ashanti – middle belt), and Kade Senior High School (Eastern Region – southern belt).

These schools and their respective locations and belts are shown in Table 4.1.

Table 4. 1: Distribution of Sampled Schools within Ghana

School	Region of School	Belt Of Location
Lawra Senior High School	Upper West Region	Northern Belt
Odomaseman Senior High School	Bono Region	Middle Belt
Seikwa Senior High School	Bono Region	Middle Belt
Prempeh Senior High School	Ashanti Region	Middle Belt
Kade Senior High School	Eastern Region	Southern Belt

The participants in the study were sampled among four educational institutions. Seikwa Senior High School and Kade Senior High School each recorded the highest number of participants, totaling 114, whereas Prempeh Senior High School registered the lowest number at 5. Lawra Senior High School contributed a total of 109 participants. The student demographic constituted the predominant group within all four institutions, except for Prempeh Senior High School, where the concentration was only on teachers. Each institution provided five educators, thereby ensuring uniform representation of geography teachers across the sampled schools. In terms of administrative representation, the figures varied from three at Odomaseman Senior High School to four at the other institutions and none at Prempeh Senior High School.

Table 4.2 shows the Breakdown of Respondents by School and Category.

Table 4. 2: Breakdown of Respondents by School and Category

School (Region)	Students	Teachers	Administrators	Total
Lawra SHS (Upper West Region)	99	5	4	**109**
Seikwa SHS(Bono)	105	4	4	**113**
Odomaseman SHS (Bono)	95	5	3	**103**
Prempeh Senior High School	-	6	-	**6**
Kade SHS (Eastern Region)	106	5	4	**114**
Total	**405**	**25**	**15**	**445**

This distribution illustrates a well-balanced representation of viewpoints across the various regions and among the three stakeholder categories (students, educators, and administrators).

4.1.2 Reliability and Validity of Composite Scales

The *Student Attitudes toward GST* triad (Q12–Q14) showed good internal consistency, $\alpha = 0.789$ ($n = 405$; mean inter-item $r = 0.56$). Item–total correlations were 0.64 (Q12), 0.70 (Q13), and 0.56 (Q14). Alpha-if-dropped indicated that removing any item would not improve reliability (Q12→0.705; Q13→0.642; Q14→0.786); hence, all three items were retained. The correlation-matrix eigenvalues were 2.11, 0.54, and 0.34, with the first component explaining ~70% of total variance, evidencing a dominant single factor and supporting unidimensionality. The composite attitude score was created as the respondent-level mean of Q12–Q14 (requiring ≥2 valid responses).

4.1.3 Demographic Profile of Students

4.1.3.1 Age Distribution of Respondents

R Studio was used to examine the age distribution of the sampled students. Table 4.3 presents the frequency and percentage distribution of respondents' ages.

Table 4. 3: Frequency and Percentage Distribution of Students' Ages

Age Range	Count	Percentage (%)
13-14	13	3.2
15-16	59	14.6
17-18	248	61.2
19-20	74	18.3
21 and Above	11	2.7
Total	405	100

Figure 4.1 illustrates the Distribution of Students' ages using a bar chart.

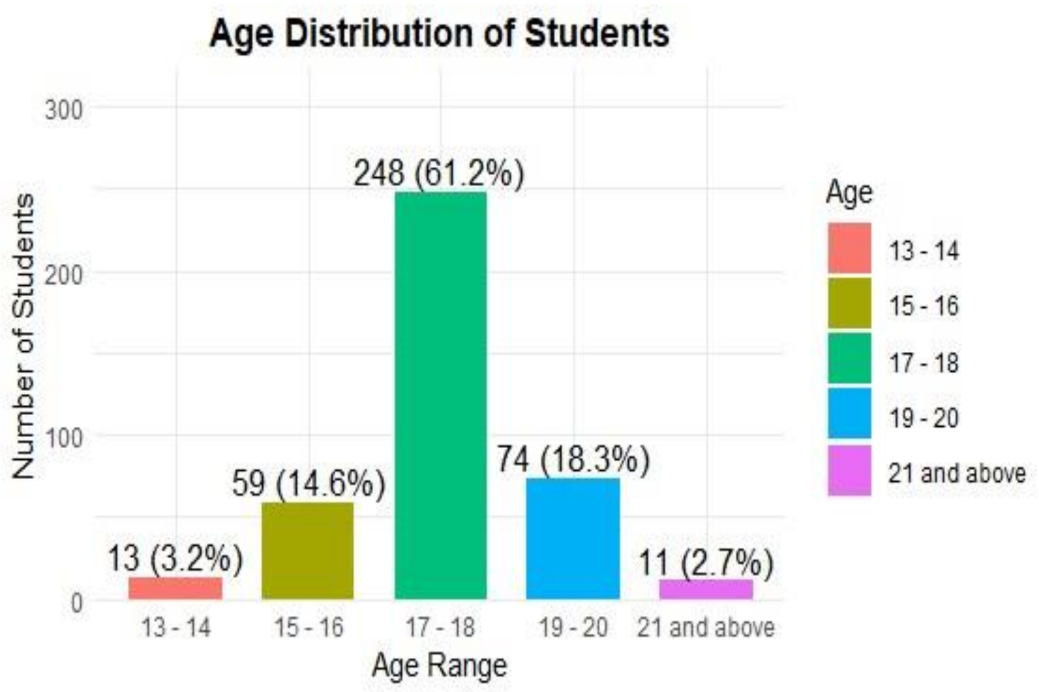

Figure 4. 1: Bar Chart Showing Age Distribution of Respondents

The age distribution of students shows that the majority fall within the 17–18 years group (61.2%), followed by the 19–20 years group (18.3%). Students aged 15–16 years account for

14.6%, while the youngest group, 13–14 years, represents only 3.2%. A small proportion (2.7%) are aged 21 years and above.

This indicates that most respondents are within the typical senior high school age bracket of 16–19 years, with the peak concentration at 17–18 years. The low representation of students below 15 or above 20 suggests that the sample is largely consistent with the expected age range for SHS students in Ghana.

4.1.3.2 Gender Distribution of Students

To understand the demographic characteristics of the student participants, the gender distribution of respondents was first analyzed in R Studio. The results are presented in Table 4.4.

Table 4. 4: Gender Distribution of Students

Gender	Frequency	Percentage
Female	213	52.6%
Male	192	47.4%

The gender distribution of students is visually illustrated in Figure 4.2.

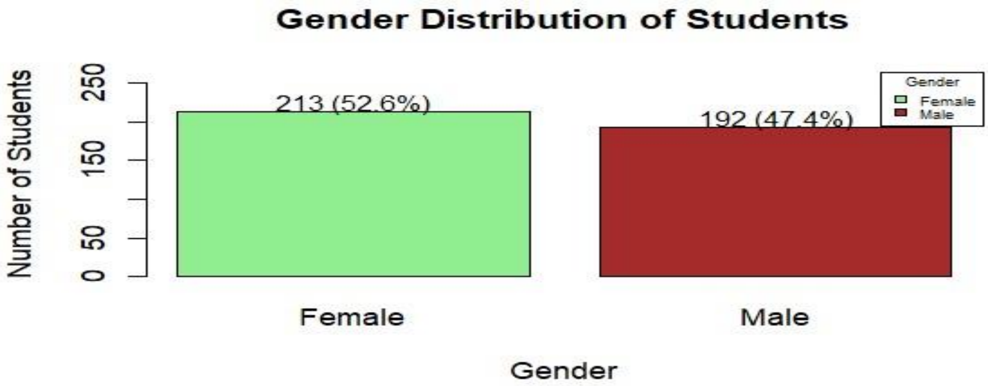

Figure 4. 2: Bar Chart Showing Gender Distribution of Students

The gender distribution of respondents reveals that a total of 213 participants, representing 52.6%, were female, while 192 participants, representing 47.4%, were male. This indicates a relatively balanced gender composition, with a slight dominance of females over males by 5.2%. The near-equal representation of both genders suggests that the data collected is less likely to be affected by gender bias and, therefore, provides a more reliable basis for concluding the study.

4.1.3.3 Class Distribution of Students

The distribution of respondents across class levels is presented in Table 4.5.

Class Level	Frequency	Percentage (%)
SHS 2	180	44.4
SHS 3	225	55.6

Table 4. 5 : Class Distribution of Students

Figure 4.3 provides a bar-chart representation of this distribution.

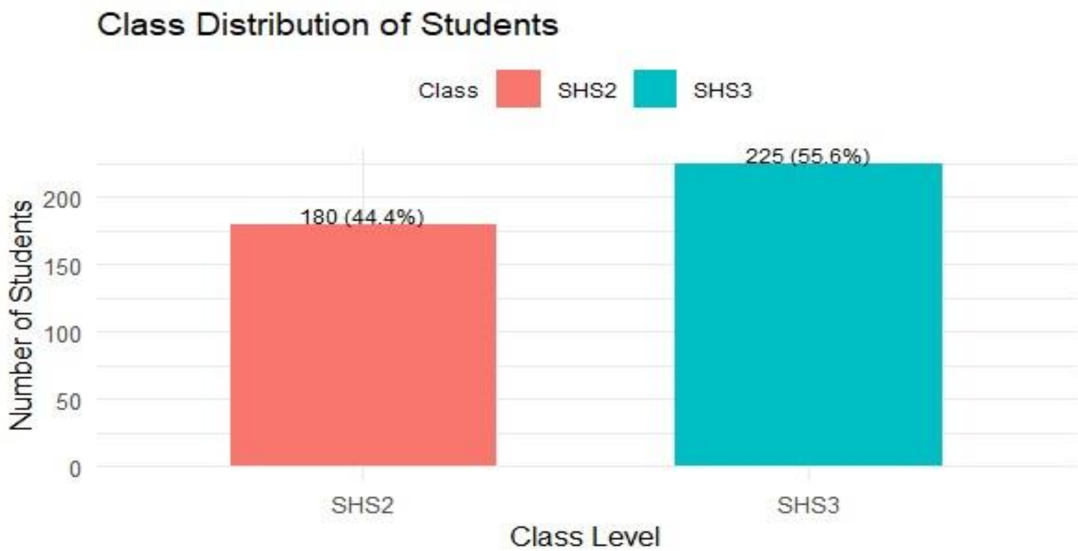

Figure 4. 3: Class Distribution of Students

The results indicate that SHS3 students formed the majority, with 225 (55.6%), while SHS2 students accounted for 180 (44.4%). This suggests that final-year students were slightly more represented in the study compared to second-year students. The relatively higher participation of SHS3 students reflects their greater exposure to geography and their availability during the data collection. Nonetheless, the distribution remains fairly balanced, ensuring that perspectives from both groups are well captured.

4.1.3.4 Spatial Distribution of Student Respondents across Study Regions

4.1.3.4.1 Total Respondents by Region

The Bono Region recorded the highest number of student respondents (200), followed by the Eastern Region (106). The Upper West Region registered the least number of respondents (99), representing 49.4%, 26.2%, and 24.4%, respectively.

Table 4.6 shows the total number of respondents per region.

Table 4. 6: Total Respondents by Region

Region	Number of Respondents	Percentages (%)
Upper West Region	99	24.4
Bono Region	200	49.4
Eastern Region	106	26.2

The same data is depicted in Figure 4.4 to show the spatial distribution of respondents on a regional basis.

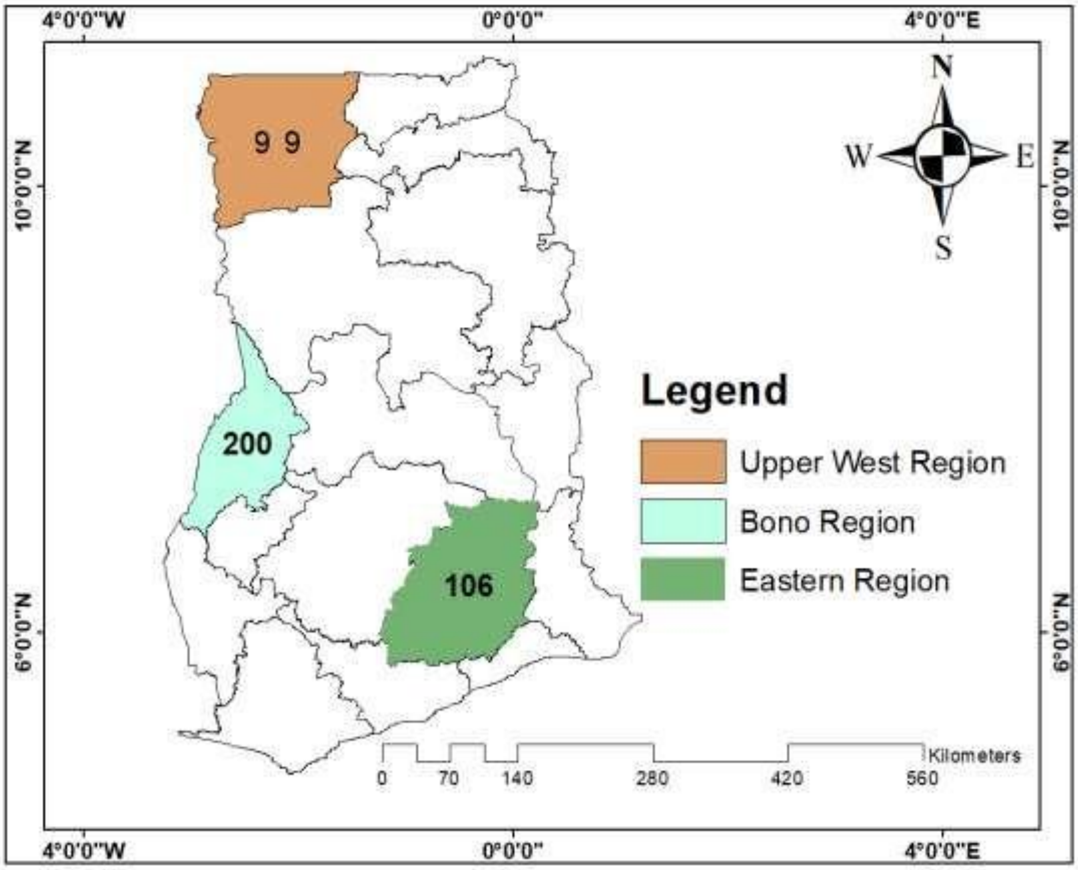

Figure 4. 4: Total Respondents by Region

4.1.3.4.2 Gender Distribution by Region

Gender distribution across the study sample regions within the study area. It shows a fairly balanced pattern with slight differences across the regions. In the Bono Region, male respondents outnumbered females, suggesting a higher male representation in the sampled schools. A similar trend is observed in the Eastern Region, where male students were also, to some extent, dominant. In the Upper West Region, however, the proportion of male and female respondents was relatively balanced.

Table 4.7 depicts gender distribution by sampled regions.

Table 4. 7 : Gender Distribution by Region

Region	Male	Female

Bono Region	70	130
Upper West Region	56	43
Eastern Region	66	40

To further understand the gender distributions by region, Figure 4.5 shows the spatial distribution of the gender of each region.

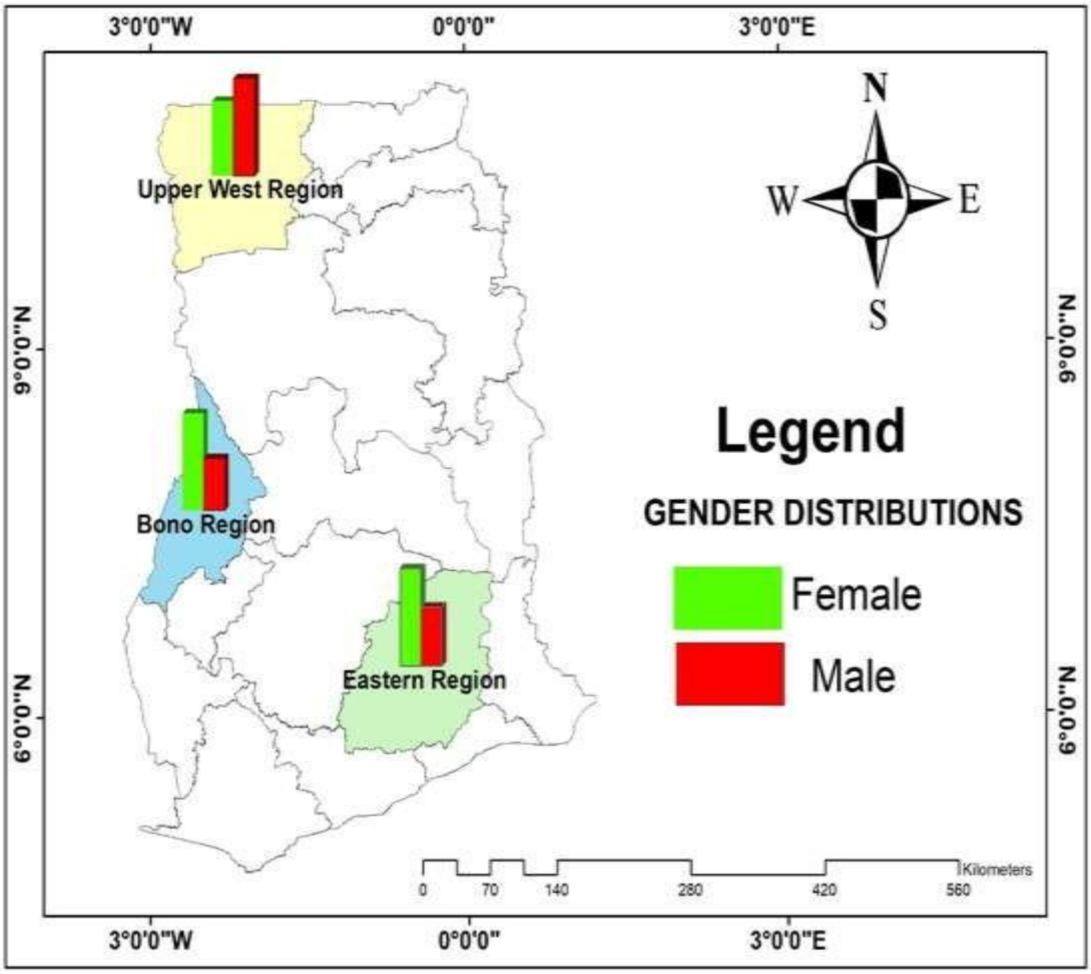

Figure 4. 5: Gender Distribution of Student

4.1.2.4.3 Class-Level Distribution by Region

Nonetheless, the distribution remains fairly balanced, ensuring that perspectives from both groups are well captured. The Bono Region recorded the highest number of SHS3 students, followed by the Eastern Region, while the Upper West Region registered the least. This pattern reflects the relatively larger presence of final-year students in the sampled schools, due to their greater availability, willingness, or encouragement by teachers to participate. The comparatively lower number of SHS2 respondents suggests reduced participation in the study.

Table 4.8 shows class-level distribution by region.

Table 4. 8: Class-Level Distribution by Region

Region	SHS2	SHS3
Upper West Region	49	50
Bono Region	116	84
Eastern Region	15	91

Class-Level distribution by region is shown in Figure 4.6.

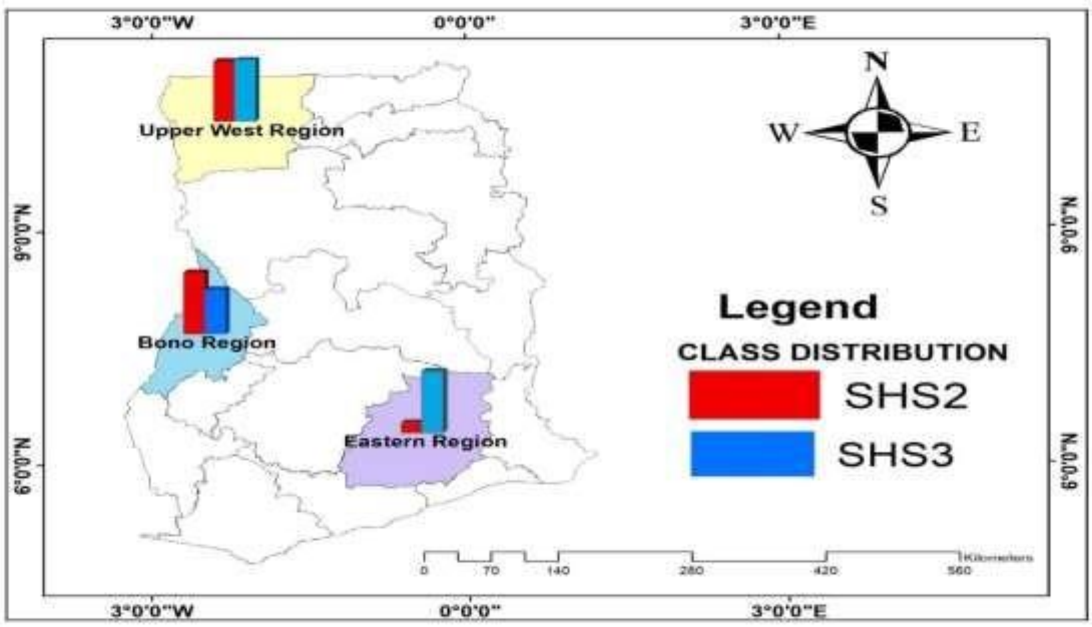

Figure 4. 6: The Class-Level Distribution by Region

4.1.3.4.4 Age Distribution by Region

The age distribution of respondents across regions largely falls within the 15–20 age bracket, consistent with the expected age range of senior high school students in Ghana. In Bono Region, the highest concentration of students was between 17–18 years, with a gradual decline in older age groups. A similar trend was observed in the Eastern and

Upper West regions, where the majority of students were between 17 and 19 years old. Very few respondents were above 20 years, indicating limited cases of late enrollment or repeated years. The distribution demonstrates how the respondents' demographics fit the typical senior high school age range.

Age Distribution of Respondents by Region on Table 4.9

Table 4. 9: Age Distribution of Respondents by Region

Region	**13-14 Range**	**15-16 Range**	**17-18 Range**	**19- 20 Range**	**21-Above Range**	**Total**
Upper West Region	7	20	42	22	8	**99**
Bono Region	5	33	129	30	3	**200**
Eastern Region	1	6	77	22	-	**106**
Total	**13**	**59**	**248**	**74**	**11**	**405**

Age Distributions of Students by Region are represented in Figure 4.7.

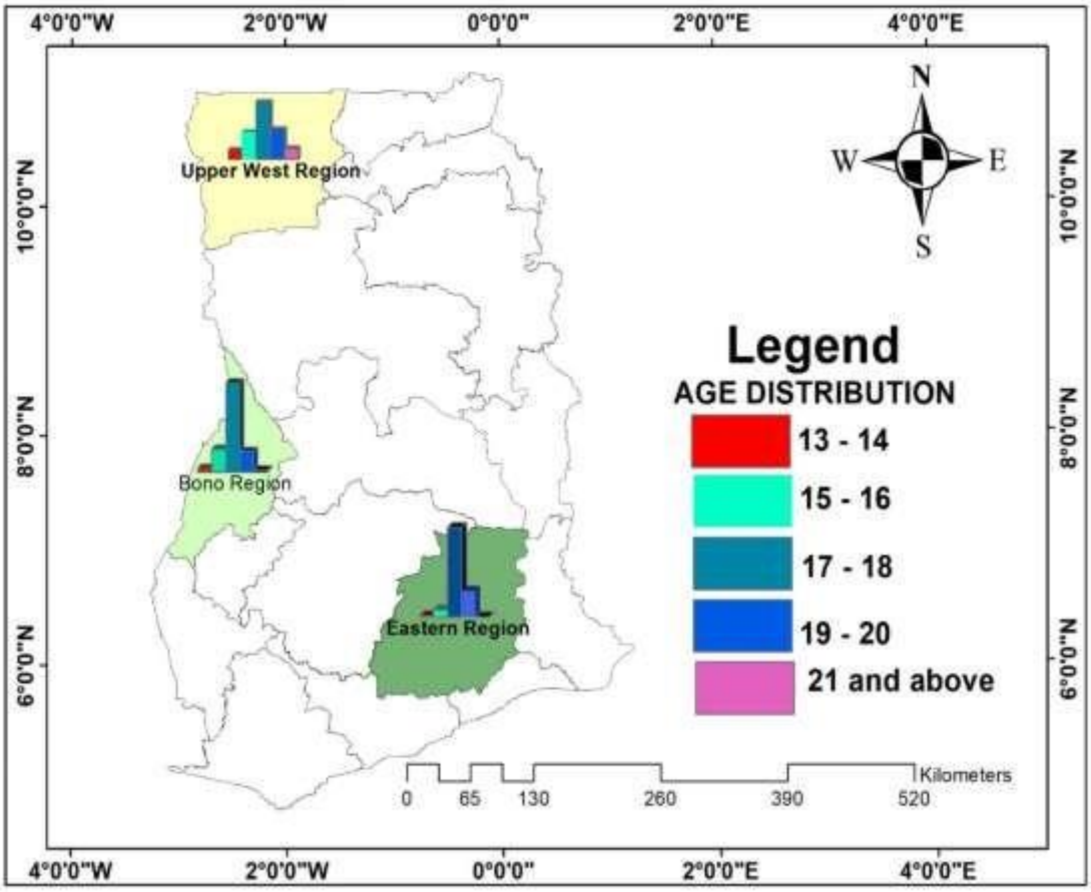

Figure 4. 7: The Age Distributions of Students by Region

4.1.4 Demographic Information of Teachers

The demographic characteristics of the teachers who participated in the study are outlined in the table generated from R Studio. The demographic details of the 25 sampled geography teachers who took part in the study are summarised here. The data presented include key indicators such as age distribution, gender composition, years of teaching experience, highest educational attainment, universities attended, and the geographic distribution of the schools where they teach. These characteristics are important for understanding the professional background of the respondents and for situating their perspectives on the integration of geospatial science and technology (GST) within the broader context of geography education in senior high schools. This information is shown in Table 4.10.

Table 4. 10: Demographic Characteristics of Teachers

Variable	Categories	Frequency	Percent
Age Teacher	19-30	8	32%
	31- 40	12	48%
	41-50	2	8%
	51-59	3	12%
	Total	**25**	**100 %**
Gender	Female	4	16%
	Male	21	84%
	Total	**25**	**100 %**
Academic Qualification	Degree	23	92%
	Master	2	8%
	Total	**25**	**100 %**
Teaching Experience	1-5 years	12	48%
	11-20 years	4	16%
	20-40 years	3	12%
	6-10 years	6	24%
	Total	**25**	**100 %**
University Completed	Other	6	24%
	Kwame Nkrumah University of Science and Technology (KNUST)	4	16%
	University for Development Studies (UDS)	1	4%
	University of Cape Coast (UCC)	13	52%
	University of Ghana (UG)	1	4%
	Total	**25**	**100 %**
Other University (Specify)	Catholic University of Ghana	1	16.7 %

	University of Winneba Education	5	83.3 %
	Total	**6**	**100 %**
Did you offer GST in your degree program	No	9	36%
	Yes	16	64%
	Total	**25**	**100 %**
Have you received any GST training?	No	9	100%
	Total	**9**	**100 %**
Region of School	Ashanti Region	6	24%
	Bono Region	9	36%
	Eastern Region	5	20%
	Upper West Region	5	20%
	Total	**25**	**100 %**

The majority of teachers, representing 48%, are between the ages of 31 and 40 years, followed by those between 19 and 30 years, representing 32%. The smaller proportions are within the 41–50 years (8%) and 51–59 years (12%) age ranges. This indicates that most of the sampled teachers are relatively young and within their productive professional years. In terms of gender, out of the 25 teachers, 21 (84%) were male, while only 4 (16%) were female. This reflects a significant gender imbalance, suggesting that geography teaching at the SHS level is still a male-dominated profession. According to the data on educational qualification, 92% of teachers hold a degree, while only 8% possess a master's degree. This suggests that while most teachers are academically qualified, few have advanced postgraduate training, which may influence their preparedness to integrate modern pedagogical tools such as geospatial science and technology.

Nearly half (48%) of the teachers have 1–5 years of experience, followed by 24% with 6–10 years. A smaller proportion have 11–20 years (16%) and 20–40 years (12%) of teaching experience. This distribution indicates that the sample is dominated by relatively early-career teachers.

The University of Cape Coast (UCC) accounts for the highest number of graduates (52%), followed by other universities (thus the University of Education, Winneba, and Catholic University, Ghana) (24%), and KNUST (16%). A few graduated from UDS (4%) and UG (4%). Among the "other universities," the University of Education (83.3%) recorded the highest, while Catholic University recorded 16%. highlights UCC's central role in training SHS Geography teachers.

About 64% of teachers responded that their universities offer GST, while 36% said their schools do not. A significant gap in teacher capacity building is suggested by the fact that none of the teachers who responded that they were not able to access GST during their training at schools also reported having not received formal training.

Teachers were distributed across the Bono Region (36%), the Ashanti Region (24%), the Eastern Region (20%), and the Upper West Region (20%), ensuring that the sample reflected geographical diversity.

4.1.4.1 Total Respondents from Teachers by Region

A total of 25 geography teachers' surveys were collected from four different Ghanaian areas. In terms of responses, the Bono area had the most with nine (36%), followed by the Ashanti region with six (24%), and the Eastern and Upper West regions each had five (20%).

The total respondents from teacher by region is illustrated in Figure 4.8.

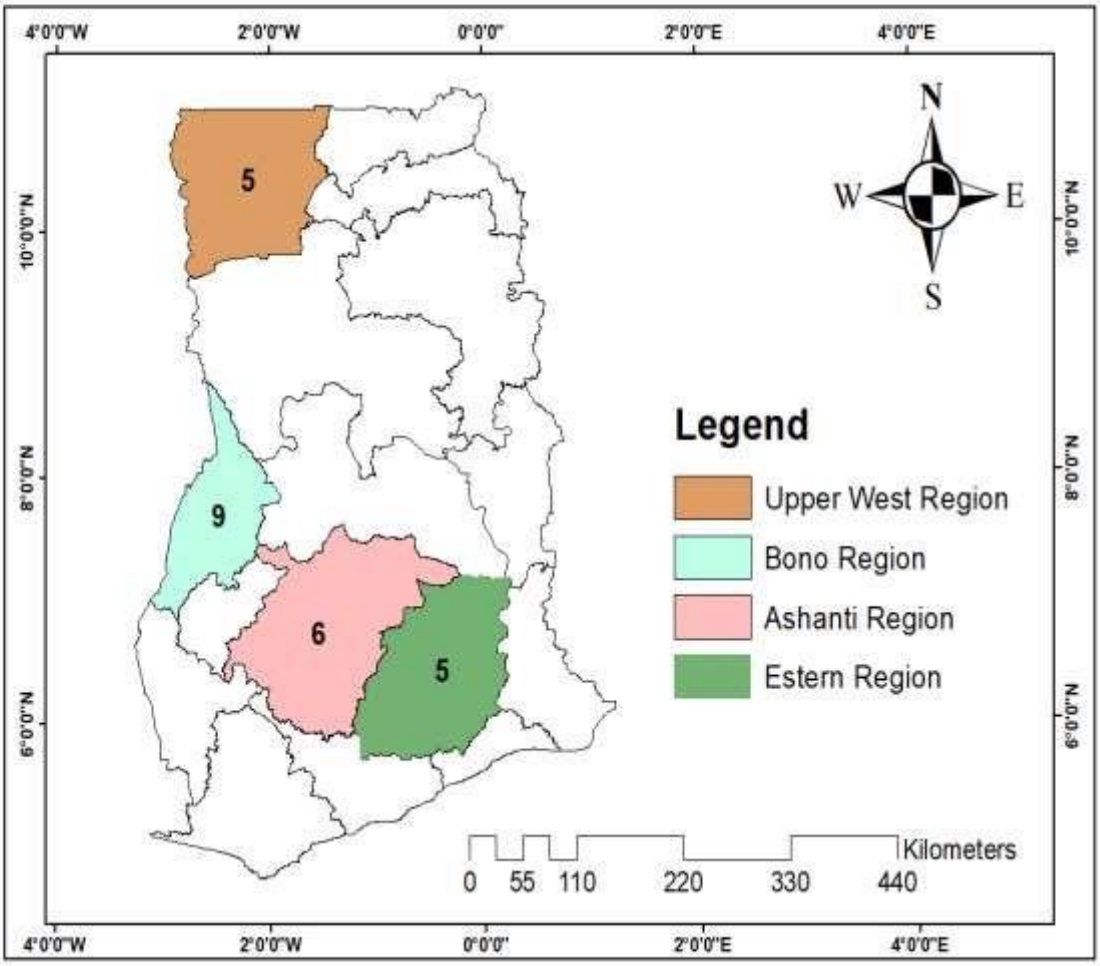

Figure 4: 8: The Total Respondents from the Teacher by Region

4.1.5 Demographic Characteristics of School Administrators

The demographic characteristics of the 15 sampled school administrators are presented in the Table. Table 4.11 summarises their gender, age, positions held in school, years of administrative experience, and regions of their schools.

Table 4. 11: Demographic Information of School Administrators

Variable	Categories	Frequency	Percent
Gender	**Female**	**5**	**33.3%**
	Male	10	66.7%
	Total	15	100%
Age	**35 – 44**	**4**	**26.7%**
	45 – 54	9	60%
	55 and above	2	13.3%
	Total	15	100%
Position	**Assistant Head (Academic)**	**2**	**13.3%**
	Head of Geography/Social Science	3	20%
	Other	10	66.7%
	Total	15	100%
Other Position (Specify)	**Assistant Headmaster Administration**	**2**	**20%**
	Guidance & Counselling	3	30%
	Senior House Master	5	50%
	Total	10	100%
Years in Administration	**5 - 10 years**	**13**	**86.7%**
	Less than 5 years	2	13.3%
	Total	15	100%
Region of School	**Bono Region**	**6**	**40%**
	Eastern Region	5	33.3%
	Upper West Region	4	26.7%
	Total	15	100%

The findings reveal that male administrators comprise the majority at 66.7%, while female administrators account for 33.3%. A significant portion of the administrators, at 60%, falls within the 45–54 age bracket, highlighting a seasoned and knowledgeable group, whereas a lesser fraction is either younger at 26.7% or older at 13.3%. Regarding their positions, most individuals (66.7%) held significant roles apart from headship or assistant headship, notably as senior house masters (50%) and in guidance/counselling positions (30%).

The leadership team had a fair amount of experience, as seen by the notable majority (86.7%) who had been in their positions for five (5) to ten (10) years. According to the geographical split, the Bono Region (40%) was the most represented, followed by the Eastern Region (33.3%) and the Upper West Region (26.7%), indicating that the data included viewpoints from different parts of Ghana.

4.1.5.1 Total Respondents from School Administrators by Region.

A total of fifteen teacher questionnaires were amassed from three distinct regions of Ghana: Bono accounted for six respondents (40%), Eastern contributed five respondents (33.3%), and Upper West yielded four respondents (26.7%).

The total respondents from school administrators by region is shown in Figure 4.9.

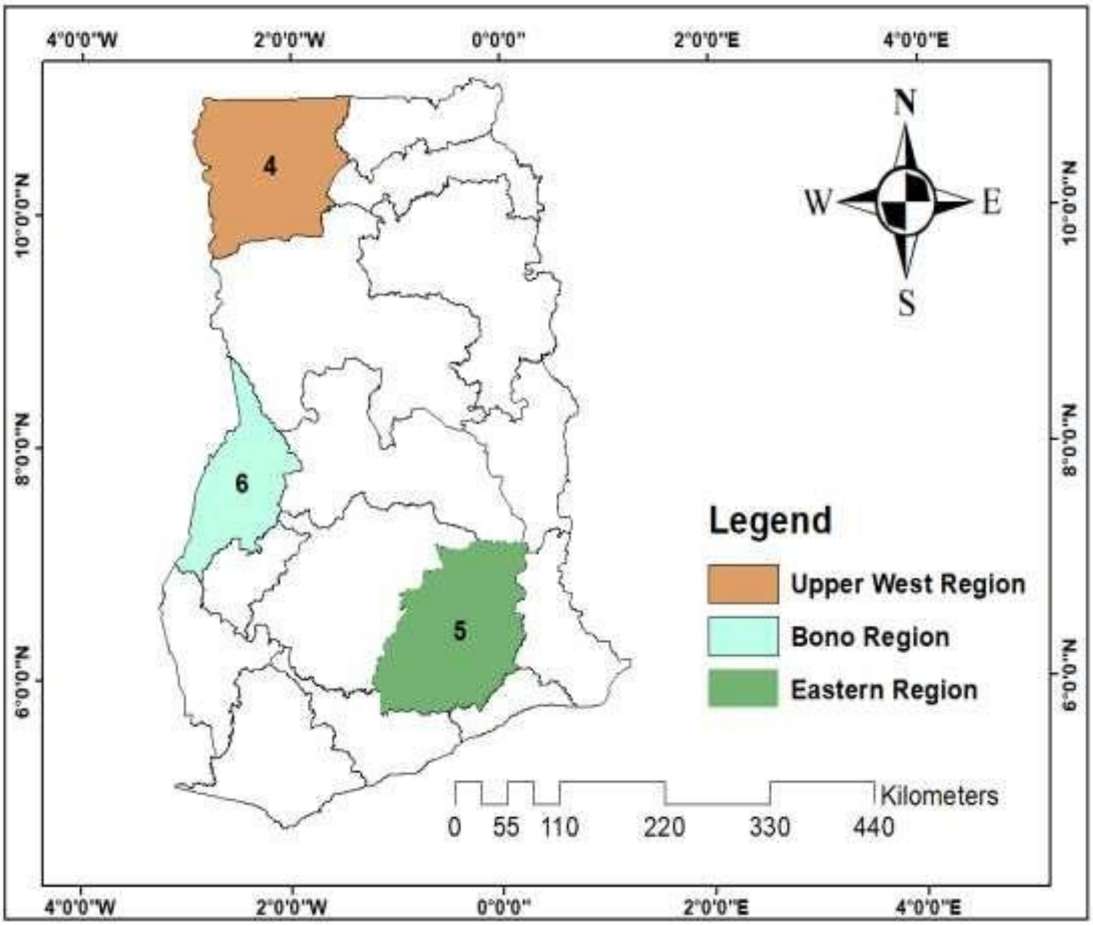

Figure 4. 9: Total Respondents from School Administrators by Region

In summary, the sample is predominantly concentrated in the central belt and northwestern areas, with Bono presenting the most substantial proportion.

4.2 Data Presentation and Analysis 4.2.1 Current level of application of GST in SHS Geography Education (Objective

1)

The current level of Incorporation of GST in Geography Education is depicted in Figure 4.10.

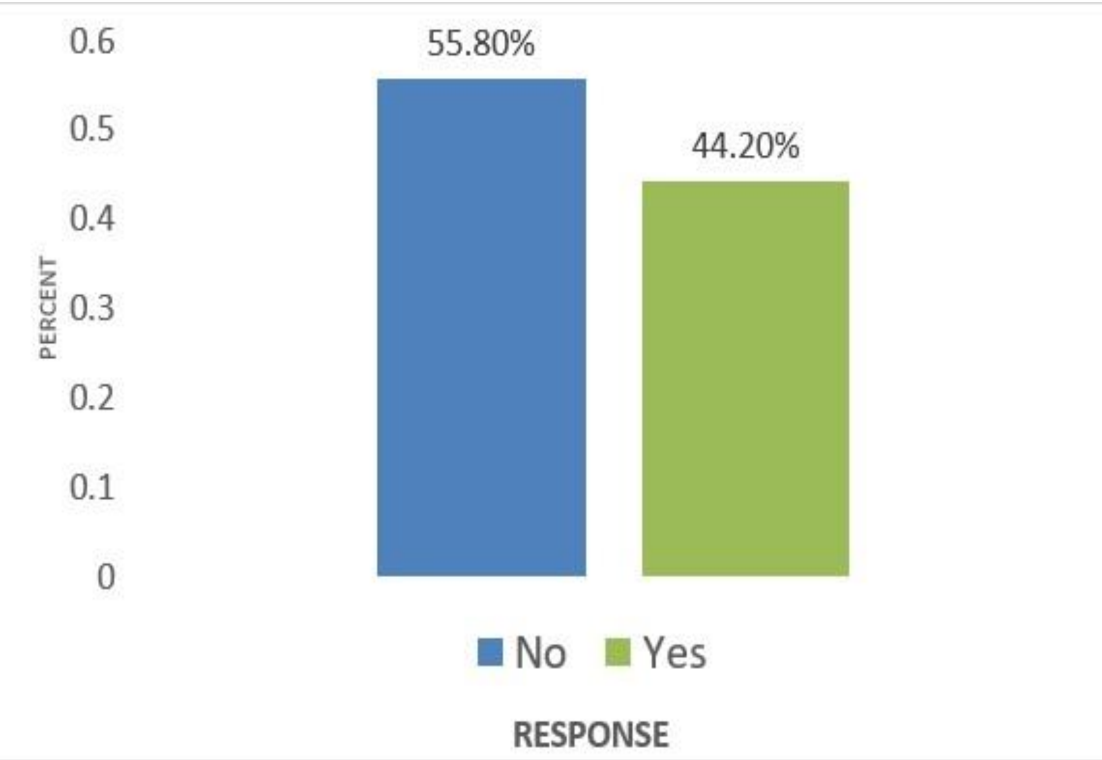

Figure 4. 10 : The Current level of application of GST in SHS Geography

Just over half of students (55.8%) say they have never used GST, while 44.2% say they have. Where it is used, it seems to rely more on online mapping tools (like Google Maps) than on whole GIS operations. These results indicate introductory, web-oriented exposure rather than comprehensive GIS practice.

4.2.2 Teacher Proficiency, Interest & Preparedness to Integrate GST (Objective 2)

4.2.2.1 Perceived Teacher GST Knowledge (Students)

The Figure 4.11 Shows Students' Perceptions of Their Teachers' Knowledge of GST

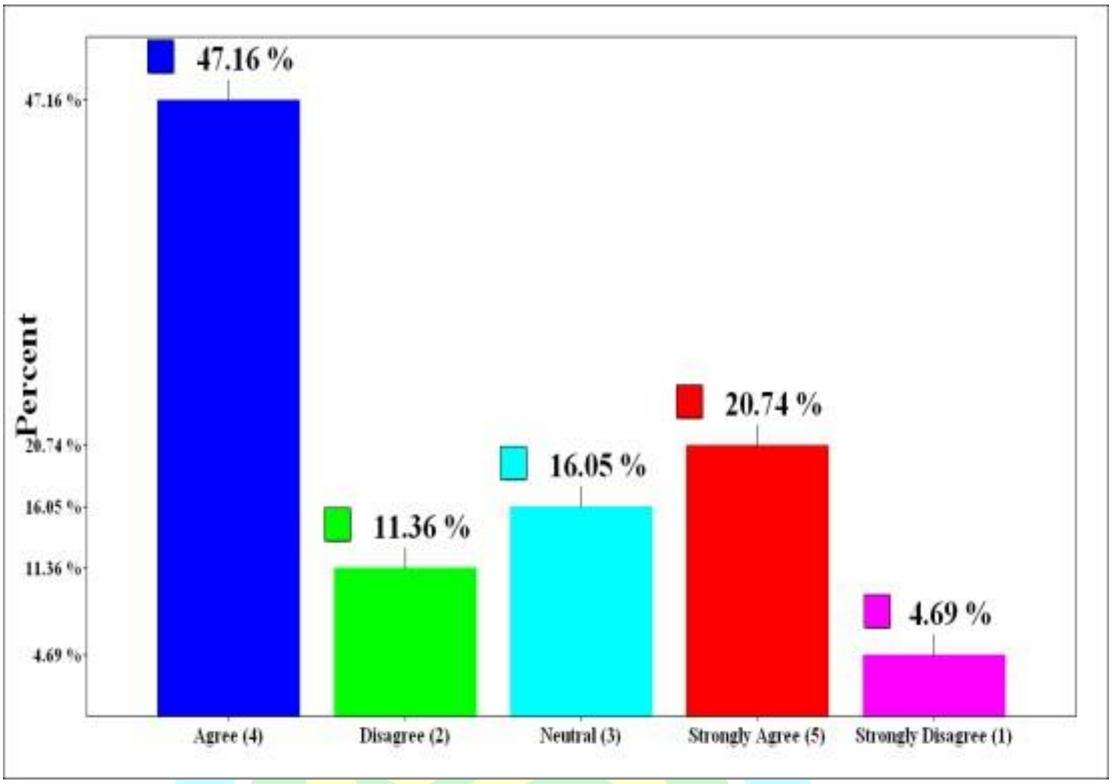

Figure 4. 11: Students' Perceived Knowledge of Teachers in GST

The evaluations provided by students regarding the statement "Teachers in my school possess a comprehensive understanding of GST" (n = 405): Strongly agree 84 (20.74%), agree 191 (47.16%), neutral 65 (16.05%), disagree 46 (11.36%), strongly disagree 19 (4.69%).275/405 = 67.90 percent is the total level of agreement (Agree + strongly agree); 16.05 percent are neutral responses, and 16.05 percent are disagreement comments. The estimated mean score for this item is 3.68/5 (SD = 1.07), indicating that students usually have a positive opinion of their teachers' GST knowledge.

4.2.2.2 Teacher GST Familiarity

The Figure 4.12 shows the Responses from teachers concerning GST familiarity.

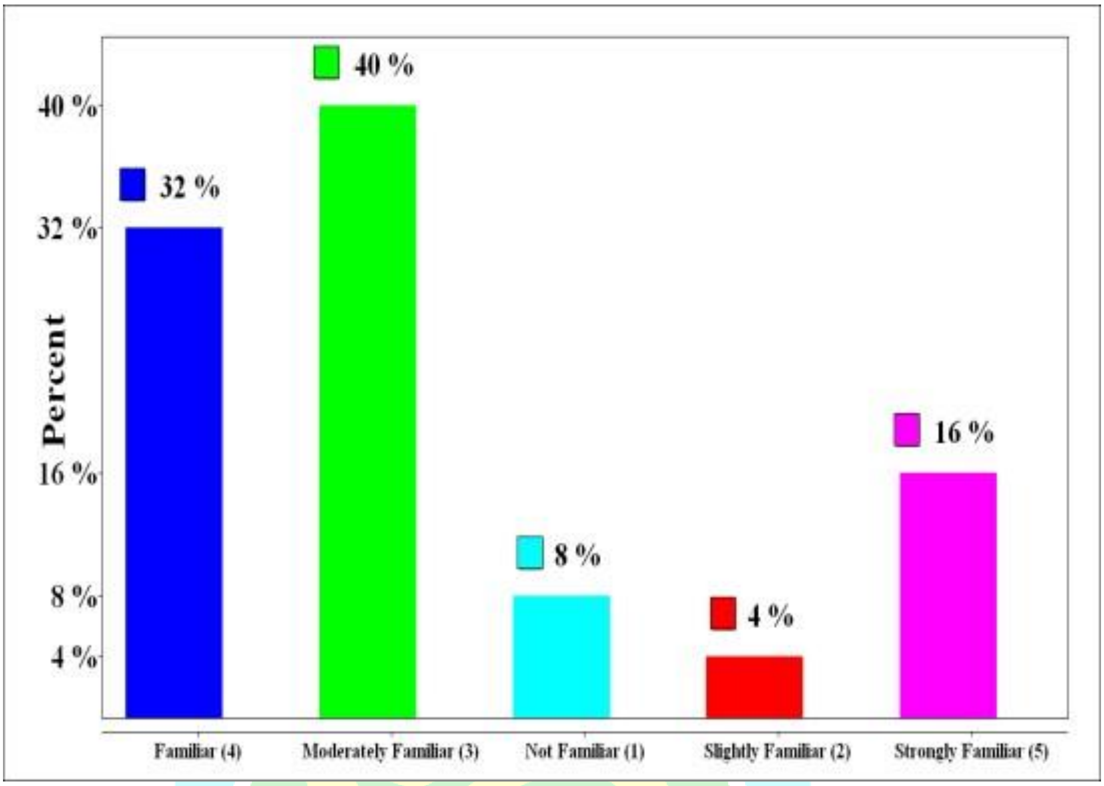

Figure 4. 12: Teacher familiarity with GST

Teachers self-reported familiarity with GST (Likert scale): not familiar 8%, slightly familiar 4%, moderately familiar 40%, familiar 32%, and strongly familiar 16%. A majority of teachers assess their familiarity as at least moderate (88%), with 48% falling within the familiar/strongly familiar category and 12% indicating low familiarity. The mean score of the item is 3.44/5 (SD ≈ 1.06), indicating a moderate overall familiarity with notable variation across respondents.

4.2.2.3 GST Course at University (Teachers)

Figure 4. 13 shows the teachers who participated in a GST-related curriculum during their initial academic degree (GIS/RS/GPS).

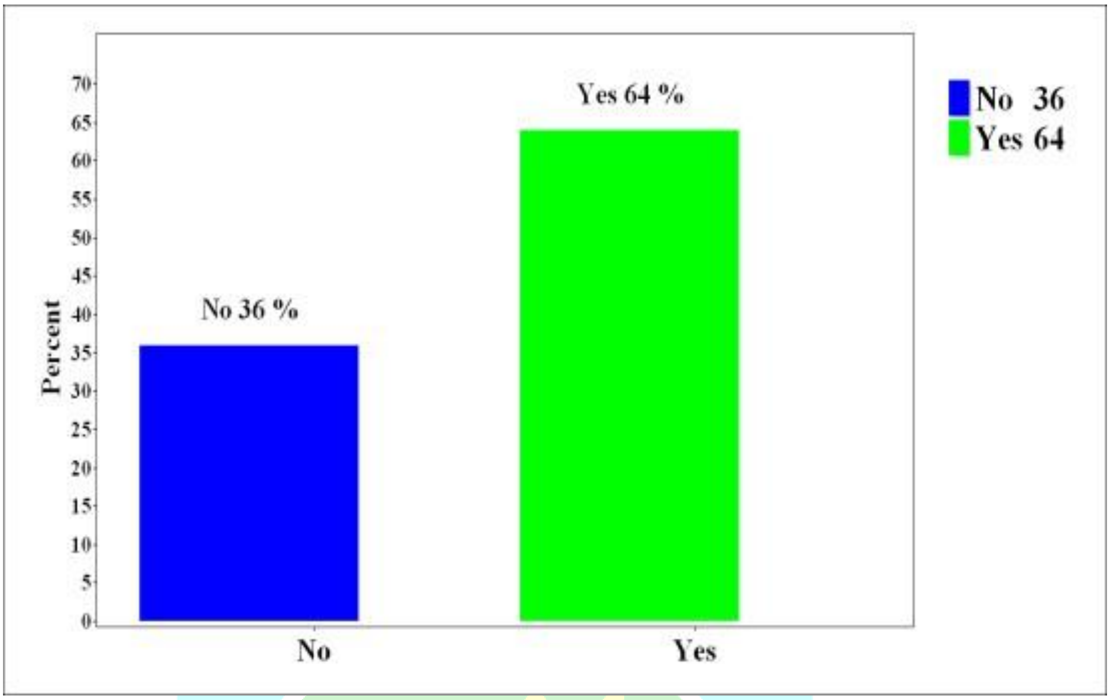

Figure 4. 13: Whether Teachers Studied any GST Course at University (Teachers)

A significant majority, 64% (16) of teachers, indicate engagement in at least one GST course during their university studies. However, more than one-third (36%) did not offer any course in GST. The training item used skip logic for teachers who indicated ‘No’ to taking a GST course in their first degree were asked whether they had received any formal GST training. The results show that all formal training reported was obtained at the undergraduate level; none of the teachers who did not take a GST course in their first degree reported any formal GST training (0%). These figures indicate uneven foundational preparation across the teaching cohort.

4.2.2.4 Teachers' Preferred Timeline for Introducing GST in SHS Geography

(Figure 4.14) shows the timeline established by educators for the integration of GST into Senior High School Geography.

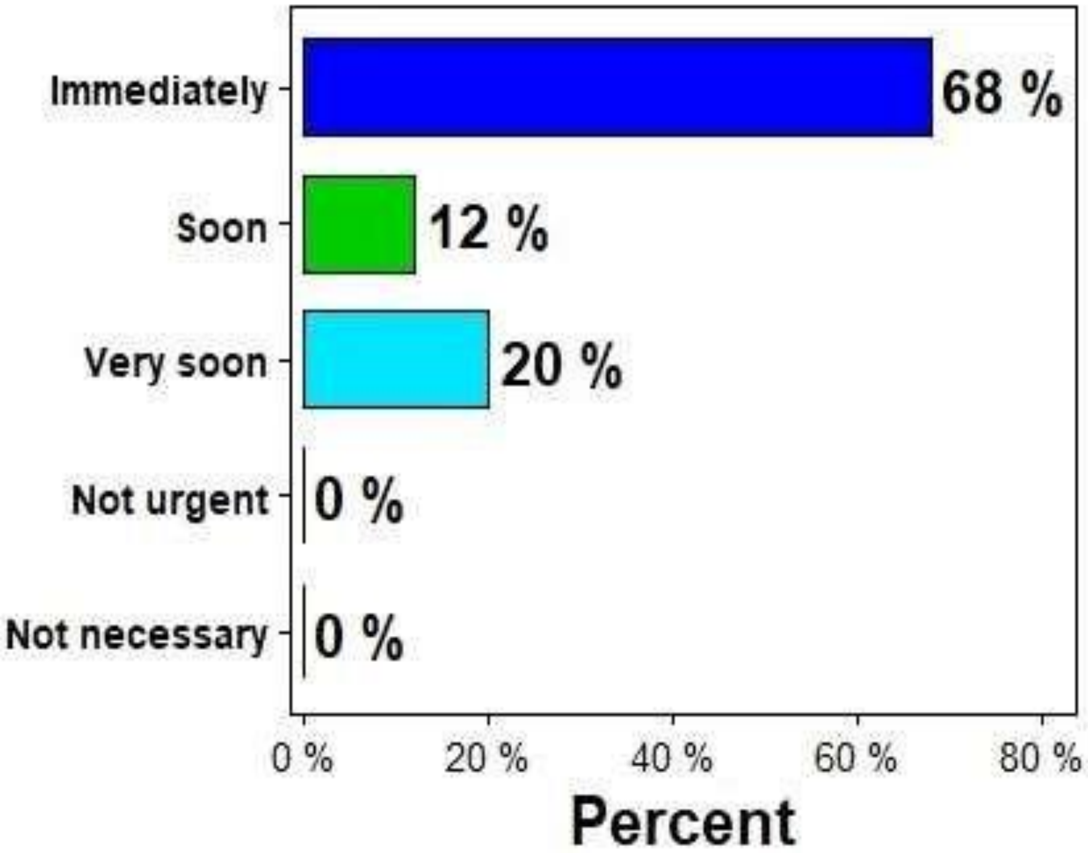

Figure 4. 14: Teachers' Preferred Timeline for Introducing GST in SHS Geography

Among teachers (n = 25), preferred timelines were immediate (≤2 years) = 68.0% (17/25), very soon (≤4 years) = 20.0% (5/25), soon (4–5 years) = 12.0% (3/25), not urgent (6–10 years) = 0.0% (0/25), and not necessary (>10 years) = 0.0% (0/25). Overall, 88.0% supported introduction within ≤4 years, and 100% within ≤5 years.

The distribution indicates strong near-term adoption preferences, with no support for deferring beyond five years.

4.2.3 Perceptions & Support of School Administrators (Objective 3)

The Views and assistance of school administrators are displayed in Table 4.12 below.

Table 4. 12: Perceptions & Support of School Administrators

Item	Scale	Base n	Percentages(Report Category)

Support inclusion of GST in SHS Geography if resources were available(Admin)	Likert(1-5)	15	Strongly disagree 0.0%; Disagree 0.0%; Neutral 0.0%; Agree 33.3%; Strongly agree 66.7%
How familiar are you with GST? (Admin)	Closedended (category)	15	Very familiar 20.0%; Not familiar at all 33.3%; Somewhat familiar 46.7%
Is GST relevant at the SHS level? (Admin)	Yes/No	15	Yes 100.0% No 0.0%
How soon should GST be introduced into SHS Geography?	Likert(1-5) Timeline	15	Immediately (≤2 years) 53.3% Very soon (≤4 years) 33.3% Soon (4–5 years) 13.3% Not urgent (6–10 years) 0.0%; Not necessary (>10 years) 0.0%
Existing school initiatives that include GST	Yes/No	15	Yes 6.7% No 93.3%

4.2.3.1 Support Inclusion of GST in SHS Geography if Resources were Available (Admin)

School administrators have conveyed a robust endorsement for the incorporation of GST into SHS geography, contingent upon the availability of resources. 66.7% of the school administrators expressed strong agreement (approximately 10), and 33.3% expressed agreement (approximately 5), with no recorded dissent. School administrators have conveyed a robust endorsement for the incorporation of GST into SHS geography, contingent upon the availability of resources. 66.7% of the school administrators expressed strong agreement (approximately 10), and 33.3% expressed agreement (approximately 5), with no recorded dissent.

4.2.3.2 Familiarity of GST (School Administrators)

Self-reported familiarity with GST exhibited variability: 20.0% identified as very familiar (approximately 3), 46.7% as somewhat familiar (approximately 7), and 33.3% as entirely unfamiliar (approximately 5).

4.2.3.3 GST Relevance at SHS Level? (Admin)

Perceived relevance was unequivocal: 100.0% deemed GST pertinent at the SHS level (15/15).

4.2.3.4 School Administrators' Preferred Timeline for Introducing GST in SHS Geography

Concerning timing, responses reflected a distinct sense of urgency: 53.3% advocated for immediate implementation (within 2 years; approximately 8), 33.3% for a very soon introduction (within 4 years; approximately 5), and 13.3% for a soon approach (4–5 years; approximately 2); responses indicating not urgent (6–10 years) and not necessary (beyond 10 years) each garnered 0.0%.

4.2.3.5 Already Existence of GST in the SHS (School Administrators)

Notwithstanding the massive support for GST integration, the prevalence of existing school initiatives that currently incorporate GST was remarkably low: 6.7% affirmed yes (approximately 1) compared to 93.3% affirming no (approximately 14).

Collectively, the results show a highly favourable disposition towards GST among administrators. Relevance: 100% judged GST pertinent at the SHS level. Timing: 53.3% preferred immediate introduction (≤2 years), and 100% supported adoption within five years. Familiarity: 20.0% reported being very familiar, 46.7% somewhat familiar, and 33.3% not familiar, indicating uneven capacity. Current initiatives: only 6.7% reported existing GST activities at the school level. Support requests: administrators prioritised software access

(93.3%), devices/GPS (73.3%), teacher training (66.7%), increased funding (66.7%), and partnerships with universities/industry (66.7%).

These data indicate a clear mandate for GST alongside practical bottlenecks, principally uneven familiarity and resource constraints that currently limit routine classroom implementation.

4.2.4 Students' Awareness, Readiness & Interest (Objective 4)

Students' awareness, and interest in GST integration are displayed in Table 4.13.

Table 4. 13: Students' awareness, readiness & interest

Item	Scale	Base n	Percentages(Report Category)
Have you heard of GST before?	Yes/No	405	Yes 74.3% No 25.7%
Where did you first hear about GST?	Closed Ended	301	School by teachers = 54.8% Internet =33.9% Friends/Family 7.0% Read from book = 4.3%
Which GST tools have you used?	Select All	301	Online Mapping Services = 63.1% GPS Devices = 20.3% GIS Software = 11.3% GPS On Smart Phones = 7.3% Remote Sensing Tools 4.3% = Other 0.0%
Integrating GST makes lessons more engaging	Likert(15)	405	Strongly disagree = 1.0% Disagree = 3.2% Neutral = 10.4% Agree = 56.3% Strongly agree = 29.1%

GST helps me understand concepts better	Likert(15)	405	Strongly disagree = 2.0% Disagree = 0.7% Neutral = 7.4% Agree = 63.7% Strongly agree = 26.2%
I am interested in learning more about GST	Likert (15)	405	Strongly disagree = 1.2% Disagree = 1.5% Neutral = 5.7% Agree = 57.3% Strongly agree = 34.3%
Learning GST benefits my future career	Likert(15)	405	Strongly disagree = 2.0% Disagree = 1.2% Neutral = 3.7% Agree = 52.1% Strongly agree = 41.0%
How soon should GST be integrated?	Timeline (1-5)	405	Immediately (≤2 years) = 72.8% Very soon (≤4 years) = 18.3% Soon (4–5 years) = 5.9% Not urgent (6–10 years) = 2.0% Not necessary (>10 years) = 1.0%
Do you support integrating GST into SHS Geography?	Yes/No	405	Yes = 99.0% No = 1.0%

4.2.4.1 Previously heard about GST (Students)

The student population exhibits considerable prior awareness of geospatial science and technology (GST). Among the 405 respondents, 74.3% acknowledged having heard of GST, while 25.7% did not.

4.2.4.2 The Source of the Initial Hearing of GST (Students)

In the group of 301 students who indicated awareness, the majority of exposure came from teachers and educational institutions (54.8%), followed by internet sources (33.9%), with smaller percentages attributing awareness to friends or family (7.0%) and literature (4.3%), respectively. This tendency highlights how important classroom interactions are in raising early awareness, especially when they are supported by digital material.

4.2.4.3 GST Resources Previously Utilized by Students

Self-reported tool use (select-all; n = 301) is significantly concentrated in online mapping services (63.1%), while GPS devices (20.3%), GIS software (11.3%), smartphone GPS capabilities (7.3%), and remote sensing equipment (4.3%) are significantly less common; 0.0% is other. As a result, while the students' practical experience is apparent, it is primarily at an elementary, web-based level rather than in more complex GIS/RS applications. Attitudes towards GST are overwhelmingly

positive.

4.2.4.4 Perceived effect of GST on interest in geography (Students)

There were 1.0 % who strongly disagreed, 3.2% who disagreed, 10.4% who were neutral, 56.3% who agreed, and 29.1% who strongly agreed with the statement, "Integrating GST makes lessons more engaging" (n = 405).

4.2.4.5 Perceived effect of GST on concept understanding (Students)

About 2.0% strongly disagree, 0.7% disagree, 7.4% are neutral, 63.7% agree, and

26.2% strongly agree with the statement, "GST aids in my understanding of concepts."

4.2.4.6 Students who are Interested in Learning more about GST

For the statement “I possess an interest in expanding my knowledge of GST,” the responses were 1.2% strongly disagree, 1.5% disagree, 5.7% neutral, 57.3% agree, and

34.3% strongly agree.

4.2.4.7 Learning GST is Beneficial for Future Career Opportunities

With the question "Learning GST is advantageous for my future career," the responses were 2.0% strongly disagree, 1.2% disagree, 3.7% neutral, 52.1% agree, and 41.0% strongly agree (all n = 405). Across the various items, the top-two agreement (agree/strongly agree) surpasses 85%, reaching a maximum of 93.1% for perceived career benefits, thereby indicating a significant perceived educational and vocational value.

4.2.4.8 Geography teachers' Preferred Timeline for Introducing GST in SHS Geography

Preferences concerning the timing of integration further indicate readiness: 72.8% went in for immediate (≤2 years) implementation, 18.3% very soon (≤4 years), and 5.9% soon (4–5 years), while merely 2.0% and 1.0% selected not urgent (6–10 years) and not necessary (>10 years), respectively (n = 405). Ultimately, the overall endorsement for the integration of GST into senior high school geography approaches unanimity (99.0% Yes; 1.0% No). Collectively, the results show a student cohort cognizant of GST and favourably inclined toward its use. Awareness was 74.3%; practical engagement was concentrated in web-based mapping (63.1%), while device/software activities were less common (GPS devices 20.3%; GIS software 11.3%; smartphone GPS 7.3%; remote sensing 4.3%). Attitudes were very positive: top-two agreement exceeded 85% across learning, curiosity, and career relevance; overall support for integration was 99%, with 72.8% preferring immediate implementation. These results indicate high readiness alongside hands-on exposure that is currently centred on low-threshold online tools.

4.2.5 Cross-Stakeholder Synthesis: Relevance, Opportunities and Obstacles of GST Integration

Table 4.14 shows the relevance, opportunities, and Obstacles of GST Integration

Table 4. 14: Relevance, opportunities & obstacles of GST integration

Sub-Item	Item Respondent's Group	& Scale	Base n	Percentages(Report Category)
Relevance	GST is Relevant at SHS (Teachers)	Likert (1-5)	25	Strongly disagree 0.0% Disagree = 0.0% Neutral = 12.0% Agree = 40.0% Strongly agree = 48.0%
Obstacle	Challenges (Students)	Select All	301	Only A Few Computers Are Available In My School = 71.8% Lack Of Access To Internet = 43.9% It Makes the Study of Geography Difficult = 5.3% Insufficient Training Or Support = 0.0% Lack Of Interest = 0.0% Other = 0.0%
Obstacle	Challenges (Teachers)	Select All	25	Insufficient Teacher Training and Expertise = 76.0% Lack of access to internet = 56.0% There are few available computers in my school = 52.0% Low Awareness and Resistance to Change 20.0% Other = 0.0%
Obstacle	Perceived challenges to integrating (GST) into SHS Geography (Administrators)	Yes/no	15	Yes 73.3% No 26.7%

Obstacle	Challenges to GST (Admin)	Select all	11	Insufficient funds for ICT infrastructure 66.7% Lack of trained teachers 53.3% Curriculum constraints 33.3% Limited internet access in some schools 26.7% Inadequate computers 13.3% Other 0.0%.
Opportunities /Benefits	Benefits (Teachers)	Select All	25	it will Enhance Awareness and Understanding of Spatial Data = 80.0% More Engaging and Practical Learning Experiences = 68.0% it will improve Career Prospects for Students = 56.0% It will Strengthen DecisionMaking and Problem-Solving Skills =48.0% Other (It will enhance creativity and innovation) = 4.0%
Opportunities /Benefits	Benefits (Admin)	Select All	15	Improve spatial thinking & analysis 66.7% Prepares students for geospatial careers 60.0% Enhances students' practical skills 53.3% Aids understanding of other subjects 26.7% other 0.0%
Support needed	Government /Stakeholder support (Teacher)	Select All	25	Insufficient Teacher Training and Expertise = 76.0% Lack of access to internet = 56.0% There are few available computers in my school = 52.0% Low Awareness and Resistance to Change = 20.0% Other = 0.0%

Support needed	Government/Stakeholder support (Admin)	Select All	15	GIS and related software = 93.3% Provision of computers & GPS devices = 73.3% Training for teachers = 66.7% More funding for GST integration = 66.7% Collaboration with universities/GIS experts = 66.7% Other = 0.0%.
Opportunity	Additional Comment from (Teacher)	Open Ended	17	Computers Devices = 23.5% Internet = Connectivity 23.5% Training PD = 23.5% Resources Funding ICT = 17.6%
Opportunity	Additional Comment from (Admin)	Open Ended	15	Teacher training & PD = 40.0% Perceived benefits (lessons will be practical) = 33.3% Careful planning / not rushed = 26.7% Resources & funding / ICT = 26.7% Stakeholder engagement / priority = 13.3% Curriculum redesign / alignment = 6.7%

Note. *Open-ended responses were thematically coded; a single response could map to multiple themes. Percentages reflect the share of respondents mentioning each theme and may exceed 100%. Base n = number of non-blank responses. Also, all "select-all" totals may exceed (100% Base n)*

4.2.5.1 Perceived Relevance of GST in Education

4.2.5.1.1 Teachers

A significant majority of educators perceive Geospatial Science and Technology (GST) as pertinent at the senior high school level: 48.0% strongly agree, 40.0% agree, and 12.0% maintain a neutral stance (n=25), with no instances of disagreement recorded. Regarding the advantages of GST, they are also consistently acknowledged. Teachers most frequently cite enhanced awareness and understanding of spatial data (80.0%), more engaging and practical learning experiences (68.0%), improved career opportunities (56.0%), and enhanced decision-making/problem-solving abilities (48.0%) with n=25.

4.2.5.1.2 Administrators

Administrators echo these sentiments, emphasizing improved spatial thinking and analysis (66.7%), preparation for geospatial careers (60.0%), enhancement of practical skills (53.3%), and facilitation of understanding in other subjects (26.7%) with n=15.

4.2.5.2 Barriers to GST Integration in Geography in SHSs.

4.2.5.2.1 Students

Students identify access barriers as opposed to attitudinal obstacles: 71.8% report a scarcity of available computers, and 43.9% indicate limited internet access (n=301), while merely 5.3% express the belief that GST would complicate the study of geography; insufficient training/support, lack of interest, and other factors all register at 0.0%.

4.2.5.2.2 Teachers

The constraints experienced by teachers closely mirror this profile: insufficient teacher training/expertise at 76.0%, lack of internet access at 56.0%, few available computers at 52.0%, and low awareness/resistance at 20.0% with n=25.

4.2.5.2.3 Administrators

A majority of administrators perceive systemic challenges (73.3% Yes, n=15), which, among those acknowledging difficulties (n=11), are predominantly centred on insufficient funding for ICT infrastructure (66.7%). A shortage of trained educators (53.3%), curriculum limitations (33.3%), restricted internet access (26.7%), and inadequate computers (13.3%).

4.2.5.3 Support from Stakeholders that the Schools Need

4.2.5.3.1 Teachers

When inquired about the support required, educators underscore the necessity for training (76.0%), internet access (56.0%), and computers (52.0%) (n=25).

4.2.5.3.2 Administrators

Administrators prioritise GIS and related software (93.3%), computers and GPS devices (73.3%), teacher training (66.7%), increased funding for integration (66.7%), and collaboration with universities and GIS experts (66.7%) (n=15).

4.2.5.4 Additional Comments from Respondents

4.2.5.4.1 Teachers

Open-ended comments substantiate these trends: teachers most frequently mention computers/devices (23.5%), internet/connectivity (23.5%), training/professional development (23.5%), and resources/funding/ICT (17.6%) with n=17.

4.2.5.4.2 Administrators

Administrators highlight teacher training and professional development (40.0%), practical lesson benefits (33.3%), careful and unhurried planning (26.7%), resources and funding/ICT (26.7%), stakeholder engagement and priority (13.3%), and curriculum alignment (6.7%) with n=15.

Across all groups, GST was rated as relevant and beneficial. Teachers reported 88% agree/strongly agree on relevance, while administrators judged GST 100% relevant. Constraints clustered around capacity and infrastructure: students cited scarcity of computers (71.8%) and limited internet (43.9%); teachers identified insufficient training (76%), limited internet (56%), and few computers (52%); administrators highlighted funding constraints (66.7%), shortage of trained teachers (53.3%), curriculum limitations (33.3%), restricted internet (26.7%), and insufficient computers

(13.3%). Reported support needs mirrored these patterns: teachers prioritised training (76%), internet (56%), and computers (52%); administrators emphasised software access (93.3%), devices/GPS (73.3%), teacher training (66.7%), increased funding (66.7%), and partnerships with universities/industry (66.7%). Taken together, the data indicate a clear mandate for GST alongside practical bottlenecks, principally devices, connectivity, and teacher upskilling, that currently limit routine classroom use.

4.2.6 Inferential Comparisons (Exploratory, Students)

Awareness × Gender. Awareness of GST differed by gender, $\chi^2(1, N = 301) = 16.29$, $p < .001$; Cramér's V = .23. Attitude × Region. Mean attitudes differed by region, $F(2, 402) = 13.89$, $p < .001$; $\eta^2 = .065$. Tukey HSD showed Upper West > Bono (mean diff = 0.37, 95% CI [0.19, 0.54], $p < .001$) and Upper West > Eastern (mean diff = 0.37, 95% CI [0.17, 0.57], $p < .001$), while Bono and Eastern ($p = .999$).

Attitude × Gender. Mean attitudes did not differ by gender, $t(397.64) = -1.70$, $p = .089$; $d = -0.17$.

Table 4.15 shows the Inferential Summary of Exploratory Tests.

Table 4. 15: Inferential Summary of Exploratory Tests (Students)

Test	Outcome	Predictor	df (df2)	N	Statistic used	p	Effect (type)
Chi-square	Awareness	Gender	1 (-)	301	16.29	< .001	0.23 (Cramér's V)
One-way ANOVA	Attitude score	Region	2 (402)	405	13.89	< .001	0.065 (η^2)
Welch t-test	Attitude score	Gender	397.64 (-)	405	-1.70	0.089	-0.17 (Cohen's d)

Note. χ^2 = Pearson's chi-square; ANOVA assumptions (normality, homogeneity) were checked; Tukey HSD available on request. Effect sizes are Cramér's V, η^2, and Cohen's *d* (small/medium/large ≈ .10/.30/.50; .01/.06/.14; .20/.50/.80).

4.3 Discussions of Findings

4.3.1 Current Level of Application of GST in SHS Geography (Objective 1)

A slight majority of students (55.8%) reported no prior experience with GST; 44.2% had some familiarity, mainly through general web-mapping tools (e.g., Google Maps). This pattern indicates nascent and largely informal exposure rather than systematic curricular integration. Classroom interactions appear to remain at introductory levels, with limited progression into data management, analysis and interpretation. An underintegration commonly associated with infrastructure constraints, limited teacher expertise, and weak curricular alignment (Acquah et al., 2017; Fleischmann et al., 2020; Osborne et al., 2020; Ridha & Kamil, 2021). At the same time, web-mapping experience among about two-fifths of students represents an accessible exposure point. International studies show that scaffolded, inquiry-oriented web-GIS activities can convert basic map use into analytical practice and improved engagement (Duarte et al., 2022; Manakane et al., 2023), and that such sequences are feasible within low-cost, open-source, or web-based ecosystems (Fleming & Evans, 2021). Overall, the baseline indicates early-stage exposure with scope for gradual deepening as capacity, materials, and curricular alignment develop (Baker et al., 2015; Mašterová, 2023).

Together with the medium regional difference in attitudes, these results indicate that facilitating conditions (infrastructure, timetable, support) shape readiness to move from map viewing to analysis, consistent with **UTAUT2** and progression beyond substitution in **SAMR**.

These results align with findings of under-integration linked to infrastructure and capacity constraints in the region (Acquah et al., 2017; Fleischmann et al., 2020;

Osborne et al., 2020; Ridha & Kamil, 2021). They diverge from cases reporting routine analytical GIS use, typically where teacher PD and stable labs are in place. Taken together, the evidence positions Ghanaian SHS practice at SAMR Substitution/Augmentation with scaffolded web-GIS activities offering a pragmatic route to Modification over time (Baker et al., 2015; Mašterová, 2023).

4.3.2 Teacher Proficiency, Interest, and Preparedness (Objective 2)

Students generally rated teachers' knowledge of GST positively (agree/strongly agree = 67.9%; $M = 3.68$, $SD = 1.07$). Teachers themselves reported a moderate level of familiarity ($M = 3.44$, $SD \approx 1.06$; 88% rated as "moderately familiar"), yet foundational training is inconsistent: 64% had taken at least one GST course during their undergraduate studies, while 36% had not, and none from that latter group reported receiving any formal training afterwards. There is a clear intent to adopt GST (68% prefer implementation within ≤2 years; 100% within ≤5 years), but intent alone is inadequate without the necessary instructional materials, time, and infrastructure. The literature consistently links sustained classroom application to the combination of preservice training and ongoing, classroom-based in-service professional development, bolstered by leadership and resources (Collins & Mitchell, 2019; Fleischmann et al., 2020).

Where prior GIS exposure exists, intentions to integrate are higher, aligning with TPACK/G-TPACK; the regional attitude gap implies capacity interacts with context. So targeted PD plus worked lesson exemplars are likely to convert intention into use.

Consistent with the TPACK/G-TPACK literature, uneven technological knowledge (TK) and limited prior geospatial coursework constrain movement beyond basic substitution tasks; where teachers report prior GIS exposure or targeted PD, stated intentions to integrate are markedly higher (Akşit, 2021; Mishra & Koehler, 2006; Salih

Yildirim, 2021). This contrasts with settings that report routine analytical GIS use, where structured, classroom-embedded PD and mentoring are in place and facilitating conditions (devices, software access) are stronger. Taken together, the evidence suggests that near-term gains in Ghanaian SHSs depend on practical, ready-to-teach web-GIS modules and micro-PD tied to syllabus topics.

4.3.3 Perceptions and Support of School Administrators (Objective 3)

Support from administrators was unequivocal: all respondents (100%) judged GST relevant for SHS; 53.3% advocated immediate implementation, and all favoured adoption within five years. Familiarity, however, was uneven (20% "very familiar"; 33.3% "unfamiliar"), and current school-level initiatives were rare (6.7%). This juxtaposition of strong intent with limited operational readiness reflects the designreality gap noted in Ghana's ICT policy context (Kubuga et al., 2021) and aligns with broader evidence that policy inclusion does not on its own yield classroom integration without institutional capacity and resourcing (Fleischmann et al., 2020; Osborne et al., 2020). Ghana-focused studies similarly highlight that, while willingness is high, institutional support structures (budgeting, procurement, and timetable/assessment alignment) often lag, constraining consistent use (Arkorful et al., 2021; Mensah et al.,

2022). Interpreted against the current GST policy (Ministry of Education (MoE), 2024; NaCCA, 2023), these findings underscore the gap between endorsement and

operational readiness.

Uniform endorsement but uneven operational readiness mirrors the regional attitude differences, pointing to facilitating conditions such as budgeting, timetable/assessment alignment, and lab/internet access as immediate levers for improvement.

These results echo UTAUT2's emphasis on facilitating conditions: leadership endorsement alone is insufficient without resourcing, timetable/assessment alignment, and procurement pathways (Fleischmann et al., 2020; Osborne et al., 2020). They diverge from cases reporting rapid uptake where school-level implementation teams, earmarked budgets, and device/connectivity minimums are in place. Taken together, the evidence situates Ghanaian SHSs in a high-intention-to-low-capacity posture. The nearterm progress hinges on converting endorsement into operational readiness, small ICT labs, phased procurement, and syllabus-tied web-GIS routines. This will enable schools

to move up the SAMR continuum from Substitution/Augmentation toward

Modification.

4.3.4 Students' Awareness, Readiness, and Interest (Objective 4)

Student awareness was high (74.3%), with schools/teachers (54.8%) and the internet (33.9%) reported as the main sources. Practical engagement was predominantly webbased: online mapping was common (63.1%), whereas device- or software-based activities were less frequent (GPS devices 20.3%; GIS software 11.3%; smartphone GPS 7.3%; remote sensing 4.3%). This pattern suggests early-stage exposure anchored in low-barrier web tools rather than equipment-intensive workflows (Duarte et al., 2022; Manakane et al., 2023).

Attitudes were overwhelmingly positive. Across engagement, understanding, eagerness to learn, and career relevance, top-two agreement exceeded 85%. Overall support for integration reached 99%, and 72.8% preferred immediate implementation. These findings are consistent with Ghana-focused studies reporting strong student appetite for interactive and visually rich learning in geography (Ntim et al., 2020; Opoku, 2019).

Taken together, the profile is one of high demand coupled with introductory skill levels, aligning with evidence that a sequenced approach beginning with web-GIS can build confidence and readiness for more demanding GPS/GIS/RS tasks as capacity and resources develop (Kholoshyn et al., 2021; Manakane et al., 2023). Despite a small-tomoderate gender difference in awareness, attitudes do not meaningfully differ by gender once exposed, suggesting exposure channels, not preferences, drive readiness, consistent with UTAUT2's perceived usefulness pathway.

These findings align with TAM/UTAUT2 evidence that high perceived usefulness and behavioural intention can precede access to equipment or formal coursework; similar patterns of strong enthusiasm alongside introductory skills are reported in other resource-constrained settings (Kholoshyn et al., 2021; Manakane et al., 2023).They differ from contexts where routine GPS/GIS/RS practice is embedded, typically supported by device availability, structured projects, and assessment alignment. Taken together, the Ghanaian SHS profile suggests a high-demand/early-skills posture in which sequenced, inquiry-oriented web-GIS activities can convert enthusiasm into capability and provide a bridge to more equipment-intensive workflows as facilitating conditions improve.

4.3.5 Cross-Stakeholder Synthesis: Relevance, Opportunities and Obstacles

Perceptions of relevance and benefits were strongly positive across groups: teachers reported high agreement on GST's value (88% agree/strongly agree), and

administrators likewise emphasised spatial thinking, practical engagement, and career readiness. Constraints, however, were practical and pervasive. Students cited scarce computers (71.8%) and limited internet access (43.9%). Teachers reported inadequate training (76%), insufficient internet (56%), and too few computers (52%).

Administrators pointed to funding constraints (66.7%), a shortage of trained teachers (53.3%), and curriculum limitations (33.3%). Taken together, these patterns indicate that the principal bottlenecks lie in capacity and infrastructure rather than attitudes, aligning with reviews and regional evidence on GIS-in-education implementation

(Fleischmann et al., 2020; Hlatywayo & Manik, 2022; Mkhongi & Musakwa, 2020; Ridha & Kamil, 2021). Ghana-focused studies similarly highlight willingness alongside gaps in technological preparedness and institutional support (Arkorful et al., 2021; Sumari et al., 2019).

Given regional attitude differences alongside strong demand, a web-GIS-first, capacitythen-scale sequence, low-bandwidth tasks, scheduled lab access, and short in-class PD should narrow gaps most efficiently.

This barrier profile is consistent with regional reviews showing that facilitating conditions, devices, connectivity, and teacher training are the dominant determinants of uptake (Fleischmann et al., 2020; Hlatywayo & Manik, 2022; Mkhongi & Musakwa, 2020). It differs from contexts reporting routine analytical GIS use, where schools operate with minimum ICT standards, dedicated PD, and ring-fenced budgets. Interpreted through UTAUT2 and SAMR, Ghanaian SHSs exhibit high relevance/low capacity: attitudes are not the binding constraint, so progress depends on converting endorsement into operational readiness, phased device procurement, reliable internet, and short, syllabus-tied web-GIS modules that can move practice from

substitution/augmentation toward modification. These findings should be interpreted with caution.

4.3.6 Summary

Overall, the findings indicate a clear mandate: students, teachers, and administrators recognise the value of GST, yet classroom practice remains early-stage and uneven, constrained chiefly by teacher capacity, infrastructure, and timetable/assessment alignment. The inferential results reinforce this pattern: a small-to-moderate gender difference in awareness but no meaningful gender difference in attitudes, and medium regional differences in attitudes, which together point to facilitating conditions as the proximate driver of readiness rather than inherent preferences. Interpreted through

TPACK/G-TPACK, limited TK–PK–CK convergence hampers progress beyond substitution; under UTAUT2, weak facilitating conditions explain uneven adoption; and within SAMR, most use remains at introductory levels. These conclusions align with prior reviews that locate the principal bottlenecks in capacity and infrastructure rather than attitudes (Collins & Mitchell, 2019; Kholoshyn et al., 2021

At the same time, several limitations should be acknowledged. The study covered five SHSs in three regions and relied on self-report questionnaires within a cross-sectional design, so the results may not capture all patterns of GST practice or change over time across Ghanaian schools. Classroom observations, analysis of student work, and longitudinal tracking of cohorts as GST is rolled out could provide richer evidence on how integration actually unfolds in practice. Future research should therefore focus less on re-establishing baseline perceptions and more on evaluating how GST integration actually unfolds in practice against this baseline. In particular, follow-up studies could track schools that begin implementing GST in phases. Starting with web-GIS and then extending to GPS, GIS, and remote sensing and examining how teacher practice, student learning, and school-level support change over time. In-depth case studies of selected SHSs, using classroom observations, interviews, document analysis, and student work, would be especially valuable for assessing which combinations of professional development, infrastructure, and leadership support most effectively move

GST from policy statements into routine SHS Geography lessons.

CHAPTER FIVE CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study set out to explore the incorporation of Geospatial Science and Technology (GST) into Senior High School (SHS) Geography in Ghana, addressing four key objectives. The study also synthesises the opportunities and obstacles that influence GST integration into the SHS Geography curriculum. It examined current classroom application, teacher capacity, administrative support, and student readiness as a prerollout baseline for the standards-based curriculum.

1. Concerning the current application (Objective 1), the findings show that GST use in SHS Geography is still limited and uneven. A substantial share of students report no prior exposure to GST at all, and where exposure does occur, it is mainly through simple web mapping rather than structured GIS GST workflows. Thus, classroom practice lags behind the curriculum's geospatial ambitions.
2. In terms of teacher capacity (Objective 2), most geography teachers perceive themselves as at least moderately familiar with GST, and many offered a GSTrelated course at the undergraduate level. However, this foundational preparation is uneven, with a sizeable minority lacking formal GST coursework and reporting no subsequent training. Despite these gaps, willingness to adopt GST is very high, with strong support for integration within the next few years, indicating that the main challenge is not attitude but sustained professional development and support.
3. For administrative support (Objective 3), school leaders regard GST as clearly relevant and strongly endorse its inclusion in SHS Geography, often favouring rapid implementation. At the same time, their own familiarity with GST varies, and concrete school-level initiatives remain scarce. Heads and other administrators point to limited funding, shortages of trained teachers, curriculum and timetable constraints, and inadequate ICT infrastructure as key obstacles to moving from endorsement to sustained practice.
4. Regarding student readiness (Objective 4), the study finds high levels of awareness, strong interest, and very positive attitudes toward GST. Students view GST as engaging,

helpful for understanding geographic concepts, and beneficial for future careers, and most wish to see it integrated into SHS Geography within a short timeframe. Yet their hands-on experience is shallow, dominated by online mapping with very limited exposure to full GIS or remote sensing tasks

5. Synthesising these strands, the study identifies a consistent pattern of opportunities and obstacles shaping GST integration. Across students, teachers, and administrators, perceived benefits include enhanced spatial reasoning, more engaging and practical learning, improved decision-making, and stronger career readiness. However, these opportunities are constrained by practical and structural barriers: shortages of computers and unreliable internet connectivity, uneven teacher preparation and limited in-service training, restricted access to software and data, and school-level budget and timetable pressures. These factors collectively prevent GST from becoming a routine part of classroom practice.

In summary, the study concludes that there is a clear mandate for GST integration in Ghanaian SHS Geography. Students, geography teachers and administrators strongly value GST and support its early implementation, but classroom use remains early-stage and uneven. The main obstacles are structural, limited devices, connectivity and professional development, rather than negative attitudes.

5.2 Recommendations

GST integration has already begun with SHS Year One under the standards-based curriculum; the recommendations below are framed to consolidate and scale this early implementation (Ministry of Education (MoE), 2024; NaCCA, 2023).

1. **Policy and Curriculum (Objective 1).** The SHS Geography syllabus should embed routine web-GIS tasks in specific topics, with GST clearly reflected in learning

outcomes, activities and assessment guidance. Sequencing should begin with simple web-GIS activities and then progress to GPS, GIS and remote sensing as capacity grows. Making GST assessable through products such as maps, story maps, and short inquiry tasks, and, where policy allows, supervised use of smartphones, will help move GST from enrichment to regular classroom work.

2. **Teacher Professional Development (Objective 2)**. Teacher capacity should be built through a structured PD pathway that prioritises staff without prior GST training. Short, classroom-embedded modules aligned to SHS Geography topics, combined with in-school resource teachers, can support immediate application. Pre-service programmes in teacher education and university geography departments should include core GST content, while peer support, co-planning, lesson study, and mentoring are institutionalised to sustain practice.

3. **Leadership and Implementation (Objective 3)**. Heads and subject leaders should be oriented on budgeting, procurement, timetabling, and light-touch monitoring so that GST is planned and resourced, not left to individual initiative. Each school should create a modest GST budget line and appoint a GST focal teacher. Implementation should follow a pilot-and-scale approach, using simple termly indicators, such as the number of GST lessons, the proportion of teachers using GST tasks and the quantity and quality of student artefacts, to guide expansion.

4. **Classroom Practice and Student Inquiry (Objective 4)**. Given students' high interest but shallow hands-on experience, geography teachers should scaffold inquiry-based learning with supervised phones and web tools, starting from "quick-win" tasks that build confidence. Practical activities such as locating features, creating basic web maps, and collecting simple field data can then be extended to more complex GIS and remote

sensing work. GST tasks should be explicitly linked to syllabus concepts and assessment criteria so that students experience GST as central to Geography learning.

5. **Infrastructure, Partnerships and Further Research (cross-cutting)**. Each school should meet a minimum ICT standard for GST, including a small pool of functioning devices, reliable internet where possible and access to at least one GIS or web-GIS platform. Low-cost tools and open data (e.g. QGIS, ArcGIS Online, and Google Earth) should be used initially, with GPS/GIS/RS equipment added as resources allow. Partnerships with universities, industry and NGOs can provide technical support, datasets and project opportunities, while future research should track the impact of PD and infrastructure investments and explore GST use across Social Studies, Science and ICT.

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APPENDIX A

TEACHERS QUESTIONNAIRES

Senior High School Geography Teachers' Perceptions of Integration of Geospatial Science and Technology in Ghanaian SHS Geography Education

INTRODUCTION

Dear Geography Teacher, This survey aims to collect data on your perceptions and opinions regarding the integration of

Geospatial Science and Technology (GST) in Senior High School geography education in Ghana. Your responses will be valuable in shaping recommendations for policy and curriculum development. All responses will be kept confidential and used solely for research purposes

SECTION A: DEMOGRAPHIC INFORMATION

1. Gender Enter your sex

Female/Male

2. Age Range Enter your years

19-30, 31- 40, 41-50, 51-59

3. Highest Professional Qualification. *Select your professional Qualification*

Degree, Master, PHD

4. Years of Teaching Experience

Select the number of years you have been teaching Geography

1-5 years, 6-10 years,11-20 years, 20-40 years

5. University *Completed. Select the university you completed your first degree*

University of Ghana (UG), Kwame Nkrumah University of Science and Technology (KNUST), University of Cape Coast (UCC), University for Development Studies (UDS), University of Energy and Natural Resources (UENR), Simon Diedong Dombo University of Business and Integrated Development Studies (SDD-UBIDS), Other

6. Other Specify *Enter the name of the University you completed*

7. Did you offer any course in Geospatial Science and Technology (eg. GIS, Remote Sensing, GPS, etc.) During your first Degree?

Yes / No

8. Have you received any formal training in Geospatial Science and Technology (GIS, Remote Sensing, GPS, etc.)? Yes/ No

9. Region of your School.

Ashanti Region, Ahafo Region, Bono East Region, Bono Region, Central Region, Eastern Region, Greater Accra Region, North East Region, Northern Region, Oti Region, Savannah Region, Upper East Region, Upper West Region, Volta Region,

Western North Region, Western Region

10. Location

Stand outside for accuracy of GPS Location

Latitude (x.y °), Longitude (x.y °)

SECTION B: AWARENESS AND PERCEPTIONS OF GEOSPATIAL SCIENCE AND TECHNOLOGY

11. How familiar are you with Geospatial Science and Technology?
Strongly Familiar (5), Familiar (4), Moderately Familiar (3), Slightly Familiar (2), Not Familiar (1)

12. Do you think Geospatial Science and Technology is relevant to geography education at the senior high school level?

Strongly Agree (5), Agree (4), Neutral (3), Disagree (2), Strongly Disagree (1)

13. What potential benefits do you think Geospatial Science and Technology can bring to geography education? (Select all that apply)

It will enhance Awareness and Understanding of Spatial Data, More Engaging and Practical Learning Experiences, It will improve Career Prospects for Students, It will Strengthen Decision-Making and Problem-Solving Skills, Other

14. Other Specify *Specify other potential benefits you think Geospatial Science and Technology can bring to geography education which is not listed in 14 above.*

15. Do you foresee any challenges in integrating Geospatial Science and Technology into geography education? (Select all that apply) Insufficient Teacher Training and Expertise, Lack of access to internet, there are few available computers in my school, Low Awareness and Resistance to Change, Other

16. Specify Other. *Specify other challenge you foresee in integrating Geospatial*

Science and Technology into geography education

SECTION C: OPPORTUNITIES AND READINESS FOR INTEGRATION

17. Would you be willing to receive training on Geospatial Science and Technology for geography teaching?

Yes/No

18. What format of training would you prefer?
Workshops Courses and Hands-on Training, Online Courses and Webinars, Blended Learning (Online and In -Person), Short Certification Programs

19. What level of support do you think the government and educational stakeholders should provide to integrate?

Geospatial Science and Technology in geography education? (Select all that apply)

Provide financial support for GIS software, computers, GPS devices, and internet access, Offer workshops and training programs for geography teachers. Establish wellequipped computer labs with GIS software and reliable internet, Partner with GIS firms and universities for resources and mentorship, Other

20. *Specify Other. Specify other support you think the government and educational stakeholders should provide to integrate Geospatial Science and Technology into geography education, which is not listed in question 19 above.)*

21. In your opinion, how soon should Geospatial Science and Technology be introduced into SHS geography education? Immediately (Within the Next 2 years) 5,

Very soon (Within the Next 4 years) 4, Soon (Within 4-5 years) 3, Not urgent (After 6-10 Years) 2, Not necessary now (after 10 years) 1

SECTION D: ADDITIONAL COMMENTS

22. What suggestions do you have for the successful integration of Geospatial Science and Technology into geography education?

Enter your comments

Below is the link to kobo collect questionnaire for Teacher.

https://ee.kobotoolbox.org/single/2e9mQKKF

APPENDIX B

SCHOOL ADMINISTRATORS QUESTIONNAIRES

School Administrators' Perceptions of Integration of Geospatial Science and Technology in Ghanaian SHS Geography Education

QUESTIONNAIRE FOR SCHOOL ADMINISTRATORS INTRODUCTION

Dear Administrator, This survey aims to collect data on your perceptions and opinions regarding the integration of Geospatial Science and Technology (GST) in Senior High School geography education in Ghana. Your responses will be valuable in shaping recommendations for policy and curriculum development. All responses will be kept confidential and used solely for research purposes_

A. DEMOGRAPHIC INFORMATION

1. GENDER select your sex Male / Female

2. Age Range 20 -24, 25 -34, 35 -44, 45 -54, 55 Above,

3. Position in School: Headmaster/Headmistress, Assistant Head (Academic), Head of

Geography Department or Social Science Other

4. Specify other Enter your Position

5. Number of Years in Administration Less than 5 years, 5 - 10 years, 11 – 15, 15 and above

6. Region of your School

Ahafo Region, Western North Region, Western Region, Volta Region, Greater Accra Region, Bono Region, Bono East Region, Central Region, North East Region, Northern Region, Oti Region, Savannah Region, Ashanti Region, Upper East Region, Upper West Region, Eastern Region

7 GPS Location

Latitude (x.y °), longitude (x.y °), altitude (m) accuracy (m)

SECTION B: AWARENESS AND PERCEPTIONS OF GEOSPATIAL SCIENCE AND TECHNOLOGY

8. How familiar are you with Geospatial Science and Technology (GIS, Remote Sensing, GPS, etc.)?

Very familiar, Somewhat familiar, Not familiar at all

9. Do you think there may be the challenges in integrating Geospatial Science and Technology into geography education?

Yes / No

10. What do you think may be the challenges in integrating Geospatial Science and Technology into Geography education? (Select all that apply)

Lack of trained teachers who can use GST, Insufficient funds for ICT infrastructure, Inadequate computers, Limited internet access in some schools, Curriculum constraints, other

11. Specify other challenges in integrating Geospatial Science and Technology into geography education which is not mentioned in question 10

12. Do you think Geospatial Science and Technology is relevant to geography education at the senior high school level?

Yes No

13. What benefits do you think Geospatial Science and Technology (GIS, GPS etc) can bring to geography education? (Select all that apply)

It will improve spatial thinking and analysis, enhance students' practical skills, it Makes geography lessons more interactive and engaging, it will prepare students for careers in geospatial industries, Aid in the proper understanding of other subjects other

14. Specify other. What other benefits do you think Geospatial Science and Technology (GIS, GPS etc) can bring to geography education? That is not mentioned in question 13 above

SECTION C: OPPORTUNITIES AND READINESS FOR INTEGRATION

15. Would you support the inclusion of Geospatial Science and Technology in the SHS geography curriculum if resources were available?

Strongly Disagree (1) Disagree (2) Neutral (3) Agree (4) Strongly Agree (5)

16. Are there any existing programs or initiatives in your school that include Geospatial Science and Technology? Yes/No

17. What kind of support would your school need to successfully implement Geospatial Science and Technology in Geography Education? (Select all that apply) (Select all that apply)

Training for teachers, Provision of Geographic Information System (GIS), software, and other software, more funding for Geospatial Technology (GST), integration, Collaboration with universities & GIS experts, Provision of Computers and GPS Devices, and Other.

18. Specify other Specify the other kind of support your school would need to successfully implement Geospatial Science and Technology. That is not mentioned in question 17 above.

19. In your opinion, how soon should Geospatial Science and Technology be introduced into SHS geography education?

Immediately (within the next 2 years) 5 Very soon (within the next 4 years) 4 Soon (within the next 4-5 years) 3 Not Urgent (After 6-10years) 2 Not Necessary now (after 10 years) 1

SECTION D. ADDITIONAL COMMENTS

20. What are your suggestions for the successful integration of Geospatial Science and Technology into geography education in the Ghanaian SHS?

LINK TO THE SCHOOL ADMINISTRATORS

https://ee.kobotoolbox.org/x/B9dstgGp

APPENDIX C

GEOGRAPHY STUDENTS QUESTIONNAIRES

Students' Perceptions of Integration of Geospatial Science And Technology in Ghanaian SHS Geography Education

QUESTIONNAIRE FOR STUDENTS INTRODUCTION

Dear Student, This survey aims to gather your perception on the use of Geospatial Science and Technology (GST), such as Geographic Information Systems (GIS), Remote Sensing, and GPS, in Senior High School geography classes in Ghana. Your feedback is important for enhancing geography education. Participation is voluntary, and your responses will remain confidential.

DEMOGRAPHIC INFORMATION

1. AGE choose your age range 13 - 14 15 - 16 17 - 18 19 - 20 21 and above

2. Gender select your Sex. Male/Female

3 . Form enter your level SHS1 SHS2 SHS3

4. Region of School Which Region in Ghana is your school located

Ahafo Region, Ashanti Region, Bono Region, Bono East Region, Central Region Eastern Region, Greater Accra Region, Upper East Region, Upper West Region, Volta Region Western Region, Western North Region, North East Region, Northern Region,

Oti Region, Savannah Region

5. GPS LOCATION latitude (x.y °) longitude (x.y °) altitude (m) accuracy (m) **SECTION B: AWARENESS AND EXPERIENCE WITH GEOSPATIAL SCIENCE AND TECHNOLOGY (GST)**

6. Have you heard of Geospatial Science and Technology (GST) (e.g., GIS, Remote Sensing, GPS) before? Yes / No

7. Where did you first hear about Geospatial Science and Technology (GST)

   School by teachers, Internet Friends/Family, Read from book, other

8. Other: Specify where you first heard about Geospatial Science and Technology (GST) that is not listed in 7 above.

9. Have you ever used Geospatial Science and Technology (GST) in your Geography class? Yes /No

10. Which tool of Geospatial Science and Technology have you used before? (Select all that apply)

    GIS software GPS devices, Remote Sensing tools, online mapping services (e.g., Google Maps), GPS coordinates applications on smart phones, other

11. Specify other Geospatial Science and Technology you have ever used that *was not mentioned in question 10 above.*

SECTION C: PERCEPTIONS OF GEOSPATIAL SCIENCE AND TECHNOLOGY (GST) IN GEOGRAPHY EDUCATION

Please indicate your level of agreement with the following statements Strongly Disagree

12. Integrating Geospatial Science and Technology (GST) makes/will make geography lessons more engaging

Strongly Disagree (1) Disagree (2) Neutral (3) Agree (4) Strongly Agree (5)

13. Using Geospatial Science and Technology (GST) helps or will help me understand geographic concepts better.

Strongly Disagree (1) Disagree (2) Neutral (3) Agree (4) Strongly Agree (5)

14. I am interested in learning more about Geospatial Science and Technology (GST). Strongly Disagree (1) Disagree (2) Neutral (3) Agree (4) Strongly Agree (5)

15. Teachers in my school are knowledgeable about Geospatial Science and Technology (GST). Strongly Disagree (1) Disagree (2) Neutral (3) Agree (4) Strongly Agree (5)

16. I believe that learning Geospatial Science and Technology (GST) can be beneficial for my future career opportunities

(1) Disagree (2) Neutral (3) Agree (4) Strongly Agree (5)

Choose all that apply.

17. When using Geospatial Science and Technology (GST) in your geography lessons, what challenges have you encountered or do you foresee? (Select all that apply.) Lack of access to internet, only a few computers are available in my school, It makes/will make the study of Geography difficult, Other

18. Other Specify

19. In your opinion, how soon do you think Geospatial Science and Technology (GST) be integrated into Senior High School Geography Education

Immediately (within the next 2 years) 5 Very soon (Within the next 4 years) 4 Soon (within the next 4-5 years) 3 Not urgent (within the next 6-10 years) 2 Not Necessary Now (After 10 years)

SECTION D: ADDITIONAL COMMENTS

20. Do you recommend or support the ideal that Geospatial Science and Technology (GST) should be integrated into SHS Geography Education? Yes No

STUNDENTS QUESTIONANAIRE LINK https://ee.kobotoolbox.org/x/MEojWr9o

APPENDIX D

RELIABILITY TEST

```
# Appendix D — Reliability for Attitude Scale (Q12–Q14), base R

# Requires packages readxl, janitor

library(readxl) library(janitor)

# --- 0) READ DATA (edit the path or bind your data frame as df_stu) --- path <-
"path/to/STUDENT_QUESTIONNAIRE.xlsx"  # <- change to your file df_stu <-
read_xlsx(path, sheet = 1, .name_repair = "unique_quiet")
# --- 1) CLEAN NAMES & ENCODING ---
df_stu <- clean_names(df_stu) char_cols <- vapply(df_stu, is.character, logical(1))
if (any(char_cols)) df_stu[char_cols] <- lapply(df_stu[char_cols], enc2utf8)
# --- 2) HELPERS --- k2n <- function(x){   x <-
as.character(x)   m <- regexpr("(?<=\\()\\d+(?=\\))", x, perl =
TRUE)   y <- suppressWarnings(as.integer(regmatches(x,
m)))   if (all(is.na(y))) y <- suppressWarnings(as.integer(x))
  y } ab <- function(M){
  M <- as.data.frame(M);  M <- M[rowSums(!is.na(M)) >= 2, , drop = FALSE]   k <-
ncol(M); n <- nrow(M)   if (k < 2 || n < 5) return(list(alpha = NA_real_, rbar = NA_real_,
n = n, R = diag(k)))   iv <- sapply(M, var, na.rm = TRUE)   tv <- var(rowSums(M, na.rm =
TRUE), na.rm = TRUE)
  R  <- suppressWarnings(cor(M, use = "pairwise.complete.obs"))
  list(alpha = (k/(k-1)) * (1 - sum(iv, na.rm = TRUE)/tv),       rbar  =
mean(R[upper.tri(R)], na.rm = TRUE),
     n = n, R = R)
}
# --- 3) PICK ITEMS (Q12–Q14; case-insensitive) ---
```

```
att_cols <- grep("^q(12|13|14)\\b", names(df_stu), ignore.case = TRUE, value = TRUE)
att_cols <- att_cols[order(as.integer(gsub("\\D","", att_cols)))] stopifnot(length(att_cols)
== 3)

# --- 4) RELIABILITY + DIAGNOSTICS ---
X    <- as.data.frame(lapply(df_stu[att_cols], k2n)) res   <- ab(X) it_r <-
sapply(seq_along(X), function(j)   suppressWarnings(cor(X[[j]], rowSums(X[,-j, drop =
FALSE], na.rm = TRUE),
                use = "pairwise.complete.obs"))) a_drop <- sapply(seq_along(X),
function(j) ab(X[,-j, drop = FALSE])$alpha) print(data.frame(Item = names(X),
            Item_total_r = round(it_r, 3),
            Alpha_if_dropped = round(a_drop, 3)),       row.names =
FALSE)
R   <-  suppressWarnings(cor(X,  use  =  "pairwise.complete.obs"))  ev  <-
eigen(R)$values
cat(sprintf("Attitudes (Q12–Q14): α=%.3f (n=%d; r̄=%.2f). Item–total: %s. Eigenvalues:
%s.\n",             res$alpha, res$n, res$rbar,             paste(sprintf("%s=%.2f", names(X),
round(it_r, 2)), collapse = ", "),           paste(round(ev, 2), collapse = ", ")))
# --- 5) SCALE SCORE (require ≥2 answered) ---
df_stu$att_n    <- rowSums(!is.na(X)) df_stu$att_mean <-
rowMeans(X, na.rm = TRUE)
df_stu$att_mean[df_stu$att_n < 2] <- NA
```

RESULTS

Reliability and item diagnostics for Attitudes (Q12–Q14).

Item	Item–total r	Alpha if dropped
Q12	0.639	0.705
Q13	0.697	0.642

Q14	0.559	0.786

Notes. Cronbach's α = .789; n = 405; mean inter-item r = .56. Eigenvalues of interitem R = 2.11, 0.54, 0.34. Scores were coded 1–5 (higher = more positive); pairwise deletion used. Scale score = mean of available items, requiring ≥2 responses.

APPENDIX E

OBJECTIVE–CONSTRUCT MAP AND OPERATIONALISATION

OBJECTIVE	CONSTRUCT (DEFINITION)	KEY INDICATORS (HOW MEASURED)	EXAMPLE QUESTIONNAIRE TARGETS	SOURCES
1 Evaluate current application of GST in SHS Geography	Current application — degree, frequency, and type of GST classroom tasks	Use/no use; frequency; task types (digital mapping, spatial analysis, data visualization); in-class vs homework	Students; Teachers	Osborne et al. (2020); Manakane, Latue, & Rakuasa (2023)
2 Analyse teacher proficiency & preparedness	Teacher capacity — GIS/RS/GPS skills, confidence, prior training, access to PD (TPACK/GTPACK orientation)	Self-rated proficiency; prior coursework; certifications/workshops; confidence; PD availability and uptake	Teachers	(Mensah et al., 2022); Yıldırım & Ünlü (2021); Arkorful, Barfi, & Aboagye (2021)
3 Investigate administrative support	Administrative support — leadership perceptions, timetable/assessment alignment, resourcing	Perceived priority; timetable/lab time; assessment inclusion; budget lines; infrastructure commitments	Administrators (Heads/assistants/ICT leads)	Fleischmann & van der Westhuizen (2020)

4 Assess student readiness	Student readiness — awareness, interest, perceived relevance, prior web-GIS/GIS exposure	Awareness of GST; interest and career relevance; prior use (e.g., Google Earth, QGIS, ArcGIS Online); device/internet access	Students	Duarte et al., 2022; Manakane et al. (2023)
5 Identify opportunities & barriers	Contextual enablers/barriers — policy alignment, partnerships, open-source tools vs hardware/connectivity/data constraints	Curriculum/policy fit; university/industry links; availability of QGIS/OSM/web-GIS; computers, bandwidth, data access; staff release time	School profile items across all respondent groups	Hlatywayo & Manik (2022); Mkhongi & Musakwa (2020); Fleming & Evans (2021)

APPENDIX F

R Script for Data Cleaning

This script was used to prepare the raw dataset for analysis. It involved selecting relevant variables, checking for missing values, and ensuring that the percentages added up correctly.

```
# Load required library library(dplyr) #
Import dataset data <-
read.csv("student_age_data.csv")
# Preview the data head(data)
# Select relevant variables  age_data <-
data %>%   select(Age, Frequency,
Percentage) # Check for missing values
sum(is.na(age_data))
```

Remove rows with missing values age_data <-

na.omit(age_data)

Ensure percentages sum to 100 (allowing for rounding)

total_percentage <- sum(age_data$Percentage)

print(total_percentage) # **View cleaned data** print(age_data)

APPENDIX G

SCRIPT FOR RESULTS SUMMARY

library(dplyr) library(janitor)

Function to summarize with pretty percentages make_summary <-

function(data, var, var_name) { data %>% tabyl({{ var }}) %>%

mutate(Percent = paste0(round(percent * 100, 1), "%")) %>%

rename(Categories = 1, Frequency = n) %>%

select(Categories, Frequency, Percent) %>% mutate(Variable =

var_name,

Variable = ifelse(row_number() == 1, paste0("**", Variable, "**"), "")) %>%

select(Variable, Categories, Frequency, Percent)

}

Combined demographic table summary_table <- bind_rows(

make_summary(teacher_data, Age, "Age"), make_summary(teacher_data, Gender,

"Gender"), make_summary(teacher_data, Qualification, "Qualification"),

make_summary(teacher_data, Experience, "Teaching Experience"),

make_summary(teacher_data, University, "University Completed"),

make_summary(teacher_data, x6_other_specify, "Other University (Specify)"),

make_summary(teacher_data, q7, "Does your school offer GST?"),

make_summary(teacher_data, q8, "Have you received GST training?"),

make_summary(teacher_data, x9_region_of_your_school, "Region of School") # LAST

```
)

library(dplyr) library(janitor)
library(flextable) library(officer)

# Function to summarize with TOTAL row
make_summary <- function(data, var, var_name) {   tab <-
data %>%     mutate(temp_var = as.character({{ var }}))
%>%     filter(!is.na(temp_var) & temp_var != "") %>%
tabyl(temp_var) %>%     rename(Categories = temp_var,
           Frequency = n,
           Percent_decimal = percent) %>%     mutate(Percent =
paste0(round(Percent_decimal * 100, 1), "%")) %>%     select(Categories,
Frequency, Percent)

  # Add TOTAL row
  total_row <- tibble(
    Categories = "Total",
    Frequency = sum(tab$Frequency, na.rm = TRUE),
    Percent = "100%"
  )
  tab <- bind_rows(tab, total_row)     # Add
variable label only on first row
  tab %>%
    mutate(
      Variable = var_name,
      Variable = ifelse(row_number() == 1, paste0("**", Variable, "**"), "")
    ) %>%          select(Variable, Categories, Frequency,
Percent)
}
```

Build one combined summary table summary_table <- bind_rows(

make_summary(teacher_data, Age, "Age"), make_summary(teacher_data, Gender, "Gender"), make_summary(teacher_data, Qualification, "Qualification"),

make_summary(teacher_data, Experience, "Teaching Experience"),

make_summary(teacher_data, University, "University Completed"),

make_summary(teacher_data, x6_other_specify, "Other University (Specify)"),

make_summary(teacher_data, q7, "Does your school offer GST?"),

make_summary(teacher_data, q8, "Have you received GST training?"),

make_summary(teacher_data, x9_region_of_your_school, "Region of School")

)

Turn into a flextable ft <-

flextable(summary_table) %>%

align(align = "center", part = "all") %>% # center all text bold(i = ~ Categories == "Total", bold = TRUE) %>% # bold Total row bold(j = "Variable", bold = TRUE, part = "body") %>% # bold variable labels autofit() %>%

theme_booktabs() %>%

fontsize(size = 10, part = "all")

Save to Word doc <-

read_docx() %>%

body_add_par("Table X: Demographic Characteristics of Teachers", style = "heading 2") %>%

body_add_flextable(ft) print(doc, target =

"Teacher_Demographics.docx") **Results**

Variable	Categories	Frequency	Percent
Age	19-30	8	32%
	31- 40	12	48%
	41-50	2	8%
	51-59	3	12%
	Total	**25**	**100%**

Gender	Female	4	16%
	Male	21	84%
	Total	**25**	**100%**
Qualification	Degree	23	92%
	Master	2	8%
	Total	**25**	**100%**
Teaching Experience	1-5 years	12	48%
	11-20 years	4	16%
	20-40 years	3	12%
	6-10 years	6	24%
	Total	**25**	**100%**
University Completed	0ther	6	24%
	Kwame Nkrumah University of Science and Technology (KNUST)	4	16%
	University for Development Studies (UDS)	1	4%
	University of Cape Coast (UCC)	13	52%
	University of Ghana (UG)	1	4%
	Total	**25**	**100%**
Other University (Specify)	Catholic University of Ghana	1	16.7%

APPENDIX H

```
# ==== minimal packages ==== suppressPackageStartupMessages({

  if (!requireNamespace("readxl", quietly=TRUE)) install.packages("readxl")

  if (!requireNamespace("dplyr",  quietly=TRUE)) install.packages("dplyr")

  if (!requireNamespace("tidyr",  quietly=TRUE)) install.packages("tidyr")
```

```
  if (!requireNamespace("effectsize", quietly=TRUE)) install.packages("effectsize")

  if (!requireNamespace("officer", quietly=TRUE)) install.packages("officer")

  if (!requireNamespace("flextable", quietly=TRUE)) install.packages("flextable")

}) library(readxl); library(dplyr); library(tidyr); library(effectsize)

library(officer); library(flextable) # ==== 1) Read & prep ====

path <- "D:/kobo collecty/useful/STUDENT QUESTIONAIRE USEFUL.xlsx"

dat0 <- readxl::read_excel(path)

to_num5 <- function(x){

  if (is.numeric(x)) return(x)

  y <- suppressWarnings(as.numeric(sub(".*\\((\\d)\\).*", "\\1", as.character(x))))

  y2 <- suppressWarnings(as.numeric(as.character(x))); ifelse(is.na(y), y2, y)
}

dat <- dat0 %>%

  mutate(

    awareness = case_when(

      grepl("^y", tolower(as.character(Q9))) ~ "Yes",

      grepl("^n", tolower(as.character(Q9))) ~ "No",

      TRUE ~ NA_character_

    ),
```

```
  q12 = to_num5(Q12), q13 = to_num5(Q13), q14 = to_num5(Q14),
  n_att = (!is.na(q12))+(!is.na(q13))+(!is.na(q14)),
  attitude_score = ifelse(n_att>=2, rowMeans(cbind(q12,q13,q14), na.rm=TRUE),
NA_real_),
  gender = factor(as.character(Gender)),
  region = factor(as.character(Region))
 ) %>% select(awareness, gender, region, attitude_score)
fmt_p <- function(p) ifelse(is.na(p), NA, ifelse(p<.001, "< .001", sprintf("%.3f", p)))
# ==== 2) Tests ====
# Chi-square (Awareness x Gender)
tab <- with(na.omit(dat[c("awareness","gender")]), table(awareness, gender))
chi <- suppressWarnings(chisq.test(tab, correct = FALSE))
V   <- effectsize::cramers_v(tab)$Cramers_v
row1 <- tibble(
 Test="Chi-square", Outcome="Awareness", Predictor="Gender",
 `df (df2)`=sprintf("%d (—)", chi$parameter), `N used`=sum(tab),
 Statistic=round(chi$statistic,2), p=fmt_p(chi$p.value),
 `Effect (type)`=sprintf("%.3f (Cramér's V)", V)
)
```

```
# ANOVA (Attitude x Region)

dat_reg <- na.omit(dat[c("region","attitude_score")])

m  <- aov(attitude_score ~ region, data=dat_reg)

a  <- summary(m)[[1]]

eta <- a["region","Sum Sq"] / sum(a[,"Sum Sq"])

row2 <- tibble(

  Test="One-way ANOVA", Outcome="Attitude score", Predictor="Region",

  `df (df2)`=sprintf("%d (%d)", a$Df[1], a$Df[2]), `N used`=nrow(dat_reg),

  Statistic=round(a$`F value`[1],2), p=fmt_p(a$`Pr(>F)`[1]),

  `Effect (type)`=sprintf("%.3f (η²)", eta)

)

# Welch t (Attitude x Gender)

dat_gen <- na.omit(dat[c("gender","attitude_score")])
tt <- t.test(attitude_score ~ gender, data=dat_gen, var.equal=FALSE)

d  <- effectsize::cohens_d(attitude_score ~ gender, data=dat_gen)$Cohens_d[1]

row3 <- tibble(

  Test="Welch t-test", Outcome="Attitude score", Predictor="Gender",

  `df (df2)`=sprintf("%.2f (—)", as.numeric(tt$parameter)), `N used`=nrow(dat_gen),

  Statistic=round(as.numeric(tt$statistic),2), p=fmt_p(tt$p.value),
```

```
  `Effect (type)`=sprintf("%.2f (d)", d)

)

summary_tbl <- bind_rows(row1,row2,row3)

# ==== 3) Save to Word ====

ft <- flextable(summary_tbl)

ft <- autofit(ft)

doc <- read_docx() |>

  body_add_par("Table 4.X. Inferential Summary (Students)", style = "heading 2") |>

  body_add_flextable(ft) |>

  body_add_par("Note. χ² = Pearson’s chi-square. ANOVA assumptions checked; Tukey HSD available on request. Effect sizes: Cramér’s V, η², Cohen’s d.",

               style = "Normal")

target_path <- "D:/kobo collecty/useful/Inferential_Summary_Students.docx" print(doc, target = target_path)

cat("Saved:", normalizePath(target_path), "\n")
```

RESULTS (Inferential Summary)

Test	Outcome	Predictor	df (df2)	N used	Statistic	p	Effect (type)

Chi-square	Awareness	Gender	1 (—)	301	16.29	< .001	0.226 (Cramér's V)
One-way ANOVA	Attitude score	Region	2 (402)	405	13.89	< .001	0.065 (η^2)
Welch t-test	Attitude score	Gender	397.64 (—)	405	-1.70	0.089	-0.17 (d)

Note. χ^2 = Pearson's chi-square. ANOVA assumptions checked; Tukey HSD available on request. Effect sizes: Cramér's V, η^2, Cohen's d.