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Abstract

The proliferation of generative artificial intelligence (GAI) in education necessitates an understanding of the foundational skills required for its effective adoption and use. This qualitative interpretive case study, grounded in constructive learning theory, investigates the foundational skills needed for GAI integration in Ghanaian higher education and examines how students' skills influence their ability to interact with and utilize GAI tools effectively. Semi-structured interviews and observations were conducted with 67 students across six diverse institutions in Northern Ghana. Thematic analysis revealed critical foundational skills, including programming proficiency, data manipulation expertise, algorithmic thinking, critical thinking, and communication skills. The study highlights the unique aspects and applications of these skills within GAI contexts and emphasizes the importance of active learning, collaborative environments, and institutional support in fostering skill development. The findings contribute to the understanding of GAI integration in higher education and provide valuable insights for curriculum development, pedagogical approaches, and policy initiatives in developing countries.

Keywords
Foundational Skills, Generative AI, Ghana, Higher Education, Constructive Learning, Interpretive Case Study

Background

The current educational landscape is undergoing a paradigmatic shift because of the proliferation of artificial intelligence (AI) technologies (Bahroun, Anane, Ahmed, & Zacca, 2023). Today, AI affects many aspects of our lives and industry in areas ranging from facial recognition on mobile devices to self-driving cars (Li & Zhang, 2023; Manoharan, 2019). In the wave of this disruptive transformation is generative artificial intelligence (GAI). GAI is a subfield of AI with the ability to create completely new content from text, code, and images to sound (Kanbach et al., 2023; Labaca-Castro, 2023).

GAI has the power to revolutionize education by offering personalized learning content. It can also automate repetitive tasks and accommodate various learning styles and approaches, allowing for a better grasp of complex concepts through timely feedback (Bahroun et al., 2023). For example, when a student is facing difficulties with a challenging coding assignment, they can rely on various support options. These options include personalized explanations, alternative approaches, and customized practice problems. This support acts as a flexible 24/7 home tutor, helping students improve their understanding. In higher education today, especially in developing countries, the critical challenge is preparing and equipping students with the

knowledge and hands-on skills they need to be competitive in this AI-driven future (Singh & Hiran, 2022; Zawacki-Richter, Marín, Bond & Gouverneur, 2019).). To complement this preparedness for an AI future, educators and researchers are also required to explore the intricacies of GAI and its significance in education by considering both its potential and challenges (Alasadi & Baiz, 2023; Ng, Leung, Chu, & Qiao, 2021).
Although Ghana has incorporated Information and Communication Technology (ICT) education into its curricula at all levels, there are still implementation issues (Gunu, Nantomah, & Inusah 2022). Effective ICT integration is hampered by a lack of funding, uneven teacher preparation, and geographical differences in the availability of computers and internet connectivity (Agyei & Voogt, 2011; Asamoah et al., 2022). Furthermore, according to a Ghanaian survey, just 18.9% of teachers have ICT training, and only 11.6% of schools have access to computers (Gunu, Nantomah, & Inusah 2022). Thus, even in situations where facilities are accessible, students' ability to improve their digital abilities may be limited by a lack of resources and training.

AI has the potential to improve both the availability and quality of instructional materials, which will help students get ready for the workforce of the future. Ghana has launched governmental programs to encourage the incorporation of AI and other cutting-edge technology into education. First, the government hopes to encourage the use and implementation of AI across a variety of sectors, including education, through the Ghana AI Policy and Strategy, which was introduced in 2022 by the Ministry of Communications and Digitalization (Ministry of Communications and Digitalization, 2022). The second is the Ghana Code Club, a non-profit organization that offers kids between the ages of 8 and 17 after-school coding activities through clubs and workshops. The goal of the Ghana Code Club initiative is to empower and inspire Ghana's upcoming generation of digital innovators and creators.

The use of AI and other cutting-edge technologies in the classroom is nevertheless fraught with dangers and difficulties. These include the privacy and security of users and systems, the ethical, legal, and societal ramifications of AI, and the accuracy and dependability of the data and algorithms. The existing digital divide and inequality among different groups and regions in the country is also a challenge that hampers a national AI integration strategy. More research is therefore needed to understand the foundational skills needed by users and their effect on the uptake and continuance use of these technologies. In this study, "foundational skills" refer to the essential or core skills that are considered necessary for students to effectively engage with and benefit from GAI technologies. These skills are identified based on their relevance to GAI adoption, their impact on student learning outcomes, and their alignment with the constructive learning framework.

Though some studies explore the potential of AI in education globally, especially in areas of technological feasibility (Li & Yang, 2023; Lin, 2022; Xu & Ouyang, 2022), research specifically examining the perceptions and attitudes, adoption, and continued use of GAI in Ghanaian education generally remains scarce. Specifically, the crucial human element and how cultural and contextual factors in terms of the foundational skills needed to enable the adoption and use of GAI have been underexplored. This creates significant knowledge gaps that hinder the understanding of its true impact and integration potential. This study therefore explores the foundational skills necessary to adopt and use generative artificial intelligence (GAI) in developing countries such as Ghana. The study also explores the impact of students' foundational skills on their capacity to interact with and make effective use of GAI tools.
Our research adopts a qualitative interpretive case study approach using constructive learning theory as the theoretical lens to answer questions on:

i. What are the foundational skills necessary for the effective adoption and use of Generative AI (GAI) in Ghanaian higher education?
ii. To what extent do students' foundational skills influence their ability to interact with and utilize GAI tools effectively?

By investigating the above questions, this research provides valuable insights that can impact computing education in Ghana by informing curriculum development, enhancing pedagogical approaches, addressing skill gaps, and promoting innovation and adoption in developing countries generally. In the rest of the paper, Section 2 explains the constructive learning theory and its application in this study. Section 3 provides the case description while Section 4 explains the research methodology in terms of the philosophical assumptions, the data collection, and the analysis of findings. Section 5 provides a discussion

of the findings while Section 6 concludes by providing the implications of the study for research, practice, and policy.

Constructive Learning Theory

Constructive Learning Theory (CLT) (Piaget, 1967) and Vygotsky's (1964) social construction framework emphasize the learner's role in knowledge construction. These theories propose that individuals actively engage with new concepts, connecting them to their prior experiences and understanding, rather than being passive recipients of information. This can be achieved by integrating new information into existing mental frameworks and adjusting schemas to accommodate new knowledge.

The ICAP (Interactive, Constructive, Active, Passive) framework (Chi & Wylie, 2014) provides additional insights into the cognitive engagement required for effective learning. Applying CLT and the ICAP framework to investigate the incorporation of fundamental abilities in GAI adoption and use is useful in several ways.

First, CLT and the ICAP framework emphasize the value of learners' active participation in the learning process (Hamidani, Neo & Perumaal, 2022). In terms of GAI integration, this implies that students must take an active role in their education through interactive situations, real-world applications, and hands-on experiences. These activities promote higher levels of cognitive engagement, as outlined in the ICAP framework, leading to a greater comprehension of the fundamental abilities needed.

Second, students bring diverse backgrounds and prior knowledge to the classroom. Educators should consider students' existing understanding of the fundamental abilities required for GAI and make connections between novel concepts and familiar ideas. This aligns with cognitive theories, such as Cognitive Load Theory (Sweller, 1988), which highlight the importance of managing cognitive demands to optimize learning outcomes.

Third, Vygotsky's notion of social construction emphasizes the role of collaborative environments in facilitating learning. Peer interactions, discussions, collaborative problem-solving, and shared learning experiences can enhance the acquisition of foundational GAI skills. The ICAP framework also supports the effectiveness of interactive learning activities in promoting deep learning.

Fourth, GAI is best understood through practical sessions. CLT encourages the integration of real-world applications into the learning process. Hands-on projects, case studies, and practical exercises provide a tangible conduit for learners to develop foundational skills in a meaningful way. These activities align with the constructive and interactive levels of the ICAP framework, promoting higher cognitive engagement.
Finally, CLT encourages reflection on learning experiences. When incorporating GAI into the classroom, teachers should encourage students to evaluate their learning, identify areas for improvement, and iteratively refine their skills. This process of iteration aligns with the theory's focus on the continuous creation of knowledge and the active and constructive levels of the ICAP framework.

In conclusion, CLT, Vygotsky's social construction framework, and the ICAP framework provide a comprehensive foundation for investigating how individuals develop the fundamental abilities needed to adopt GAI. By considering learners as active constructors of knowledge and providing opportunities for interactive, collaborative, and reflective learning experiences, educators can create environments that enable individuals to navigate the complexity of GAI and increase their confidence and competency in adopting and using it. Integrating cognitive theories alongside these frameworks further enhances the understanding of how prior learning and cognitive capabilities influence the acquisition of GAI-related skills.

Research Methodology

Piaget's constructive learning theory utilized observations and clinical interviews to understand how Piaget's constructive learning theory utilized observations and clinical interviews to understand how children construct knowledge. Inspired by this approach, our study adopted a qualitative methodology that included semi-structured interviews and observations to investigate how students in Ghanaian higher education develop foundational skills for GAI adoption and use. Although our work did not involve clinical interviews,

the use of semi-structured interviews allowed for an in-depth exploration of students' experiences and perceptions.

The semi-structured interview guide consisted of open-ended questions that focused on students' experiences with GAI technologies, their perceptions of the skills needed for effective GAI adoption and use, and the challenges they faced in developing these skills. The interview questions were designed to elicit rich, descriptive responses that would provide insights into the foundational skills and their influence on students' ability to interact with GAI tools (Creswell & Poth, 2018). A comprehensive list of the interview questions can be found in Appendix A.

The data collection process took place over a period of six months, allowing for the observation of evolving interpretations and the identification of patterns and themes across the six institutions. The duration of the data collection was considered sufficient to achieve data saturation and capture a comprehensive understanding of the phenomenon under study (Guest, Bunce, & Johnson, 2006).

Case Description

The six institutions included in this study were purposively selected based on their location in three different regions of Northern Ghana: the Northern Region, the Upper West Region, and the Upper East Region. These regions represent diverse socio-economic and cultural contexts, ranging from urban to rural settings, and encompass institutions with varying levels of resources and student demographics. The 67 students who participated in the interviews were selected from across the six institutions using purposive sampling. The observation activities were tailored to each institution's unique context, depending on the GAI-related learning activities available at each site. The distribution of participants by institution and gender is as follows:

University	Male	Female	Total
University for Development Studies	7	5	12
Tamale Technical University	6	4	10
CK Tedam University of Applied Sciences	6	5	11
Bolgatanga Technical University	5	4	9
SD Dombo University of Business and Integrated Studies	7	6	13
Hilla Liman Technical University	6	6	12

Table 1: Distribution of Participants

Observations were employed to systematically observe students' regular learning activities that incorporate GAI. The observations took place in the context of group projects, individual assignments, and other GAI-related learning activities available at each institution. The specific activities observed and the criteria used for observation included students' engagement with GAI tools and their application of relevant skills. These observations provided valuable insights into how students interact with GAI in real-world educational settings.

The selection of these 67 participants from a pool of potential candidates was based on their involvement in computing-related programs and their willingness to participate in the study. The purposive sampling approach ensured that the participants had relevant experiences and insights related to GAI adoption and use in their respective institutions.

Data analysis

The data collected underwent an interpretive analysis, influenced by the principles of constructivist learning theory. To do this, the study sought not only to understand the surface-level experiences of the students but also to delve into the construction of knowledge and the interactive processes shaping students' perceptions of GAI and its role in higher education. The analytical process involved:

- Transcription and Familiarization: This was the initial step, and it involved a meticulous transcription of recorded interviews and a thorough review of observational notes. This process aligned with constructivist learning theory by highlighting the active engagement of students in constructing their understanding of topics covered in the interview guide.
- Coding and Categorization: Open coding was employed. This was conducted by dissecting the data into smaller units. This aligns with the foundational principles of constructivism that emphasize the

learner's role in organizing and categorizing information based on their existing mental models and experiences.

- Constant Comparison: The process was iterative and involved constant comparison of new data not only with existing codes but also with participants' evolving interpretations. This acknowledged the dynamic nature of knowledge construction.
- Theoretical Sampling: Theoretical sampling was also employed by selecting additional participants who could contribute to the evolving understanding of how learners actively engage with GAI.
- Thematic Analysis: Thematic analysis was then conducted to identify surface-level themes as well as the underlying constructs and mental frameworks shaping students' interpretations. This is where the constructivist emphasis on learners' active involvement in meaning-making became paramount.
- Theoretical Framework Application: Throughout the analysis, constructivist learning theory served as the foundational lens to interpret findings within the context of how learners actively constructed knowledge by emphasizing the role of prior experiences and social interactions in shaping the understanding of the participants.
- Reflexivity and Peer Debriefing: The researcher's role was not left out. The analysis incorporated reflexivity by acknowledging that researchers played a role in co-constructing knowledge with participants. After all the interview sessions, peer debriefing sessions were held, and this enriched the analysis by providing diverse perspectives.
- Triangulation: Finally, the interpretive findings from the interviews were triangulated with observational data to acknowledge the different ways in which participants actively engaged with GAI.

By allowing Constructivist Learning Theory to inform the interpretive analysis, the study unravelled not only the participants' knowledge but also how they actively constructed knowledge. This has fostered a deeper comprehension of participants' experiences in the realm of GAI within higher education contexts.

Findings

The interpretive case study across six diverse educational institutions in three geographic regions in Northern Ghana offered profound insights into the integration of GAI. Student participants' testaments through quotations underscored the emergence of critical skills that may influence the successful integration of GAI in education.

Based on a thematic analysis of interviews and observation data, several prominent themes emerged, shedding light on the crucial foundational skills necessary for effective interaction with GAI tools. The overarching themes were programming proficiency, data manipulation expertise, algorithmic thinking, critical thinking, and communication skills. These skills were identified as foundational based on their relevance to GAI adoption, their impact on student learning outcomes, and their alignment with the constructive learning framework. Through the interviews, rich insights are provided into how these skills can significantly influence students' abilities to engage with and utilize GAI technologies.

The ensuing paragraphs provide evidence of profound quotes from participants indicating the skill sets identified and the accompanying influence they have on the adoption or integration of GAI in higher education.

First, the emerging skill was programming proficiency. This is the level of expertise and competence an individual possesses in writing, understanding, and executing computer programs. In the context of our study, it specifically relates to the ability of students to effectively use programming languages. One student indicated that:

"Students who already know how to code have an easier time with generative AI modules. It seems like programming skills are really important for diving into this tech."

In line with this, it emerged that programming proficiency influences the adoption and use of GAI. This is because having a strong programming background is like having the keys to unlock the full potential of GAI. It is not just about writing code; it is about sculpting AI solutions tailored to our academic needs. "Strong programming experience" refers to a high level of proficiency in specific programming languages, extensive

experience with GAI-related programming tasks, and familiarity with relevant programming frameworks and tools. In the context of this study, students with strong programming experience are those who have demonstrated mastery of programming concepts and techniques and can effectively apply these skills to develop and customize GAI solutions to meet their academic needs.

Second, data manipulation skills emerged. This is the ability to handle data of different kinds. A student stated that:

"Working with large datasets is a bit tough for some of us, but those who are good at handling data seem to make the most out of generative AI tools for analysis."

This is supported by the fact that when you can mould and sculpt data effortlessly, generative AI becomes your artistic tool. It is not just about numbers; it is about shaping the very clay that AI transforms into meaningful insights.

Third, the ability to approach and solve problems methodically by breaking them down into logical, step-by-step procedures or algorithms (algorithmic thinking) was identified. A participant reiterated this when he said that:

"Breaking down problems into logical steps is crucial. Students who are good at it seem to get the hang of the complex algorithms behind generative AI faster."

When students possess algorithmic thinking, it is like having a compass in the generative AI landscape that guides them through intricate patterns, helping them navigate and harness AI's potential with a clarity that others might miss.

Fourth, critical thinking emerged as a skill. This is the ability to objectively analyze and evaluate information, arguments, or situations by applying reasoned and logical judgment. This was evident in a participant's statement that:

"Some of us struggled to critically assess the outputs generated by AI. It shows that having strong critical thinking skills is important for using AI responsibly."

Through critical thinking, participants question outputs and dig deeper into the algorithms, and in doing so, they shape generative AI to be a more insightful collaborator.

Fifth, communication skills emerged as a profound skill and were supported by a participant's assertion that:

"Collaboration goes smoother for those of us who can communicate well. It really highlights how important communication skills are, especially when working on group projects with generative AI."

Through communication skills, GAI can be seen as a tool and a collaborator. This is because articulating ideas and understanding AI's responses are like having a seamless conversation, and so clear communication is the bridge to unlocking its true potential.

Learning adaptability, which refers to an individual's capacity to adjust and thrive in diverse and changing learning environments, was identified as another skill.

"Keeping up with the developments in generative AI is tough and makes being adaptable in learning a core ability needed for using this technology effectively," said one participant, confirming this. Developing the ability to adapt can help one's AI capabilities match their evolving needs.

Discussion of Findings

The fundamental skills uncovered in this case study have a significant impact on how students interact with and use GAI tools in Ghanaian higher education. It emerged that an understanding of programming is essential to realizing GAI's full potential (Prather et al., 2023). This emphasizes the critical importance of coding skills by allowing students with strong programming experience to create AI solutions that are customized to their academic needs. Expertise in data manipulation was also discovered to have a significant impact. Students can fully utilize GAI tools for analysis once they have mastered handling massive datasets. Through proficient data manipulation and analysis, experts can train AI models to produce innovative outputs, unlocking the full potential of GAI, as confirmed by earlier studies (Brock & Wangenheim, 2019).

Students can be directed through the complex patterns of GAI through algorithmic thinking, which will enable them to explore and make use of its potential (Yilmaz & Yilmaz, 2023). Empirical data indicates that algorithmic thinking is essential for creating successful problem-solving techniques in AI applications (Olkhova, 2022). Students view GAI as a perceptive partner, and critical thinking abilities are essential as they probe, examine, and mould its output. Prior research highlights the need for critical thinking to guarantee the conscientious and moral application of AI (Silapachote & Srisuphab, 2016). By enabling seamless cooperation and comprehension of AI responses, strong communication skills can unlock the full potential of generative AI. This is consistent with research showing that successful AI integration depends critically on excellent communication (Holstein et al., 2022).

The findings align with existing literature and emphasize the significance of foundational skills in shaping students' interactions with GAI tools in higher education. In addition to assessing competency, these abilities also highlight significant relationships that affect the general efficacy of AI integration.

Conclusion

The research has implications for research, practice, and policy. In terms of implications for research, the study suggests that foundational skills significantly influence the adoption and utilization of GAI. Therefore, future research should delve deeper into the specific nuances of each foundational skill. Longitudinal studies may also shed light on how pupils' core skills change over time and what effects they have. This is significant since GAI is a quickly changing phenomenon as well. A longer-term investigation would enhance our understanding of how to gain skills and adapt to the quickly evolving field of GAI. Lastly, comparative research in various cultural and educational contexts may also show differences in the significance and influence of basic skills. This is significant because contextualized techniques for various learning settings can be informed by an awareness of these variances.

The practical implications of this research include that educational institutions should think about incorporating training modules that are tailored to target the core skills that have been discovered. Students would be more prepared to use GAI technology throughout their academic careers because of these training programs. Students can be more proficient in using GAI tools if they participate in skill-building programs or workshops that emphasize programming, data manipulation, algorithmic thinking, critical thinking, and communication skills. Finally, a collaborative learning atmosphere can help students develop a collaborative mindset and a feeling of adaptability. Institutions of higher learning need to design environments that support collaboration, dialogue, and cooperative problem-solving.

It is advisable to promote the incorporation of foundational skills relevant to GAI into educational policies, including those about curriculum development, faculty training, and resource allocation. The accessibility and equitable aspects of learning core skills should be covered by other policies. To do this, measures should be taken to guarantee that students from various backgrounds have an equal chance to acquire these abilities, ultimately resulting in a decrease in the gaps in AI literacy. Lastly, cooperative strategies with GAI-affected organizations can help to ensure that educational programs are in line with industry standards. The practical relevance of educational activities can be improved through this collaboration. Despite these, the study's generalizability to a larger population may be limited due to the specific sample and context of Ghanaian computing education. Also, the dynamic nature of generative AIs might necessitate future studies to adapt to advancements in generative AI tools.

In conclusion, the study's ramifications go beyond scholarly discussion and provide useful information for researchers, educators, and decision-makers. Stakeholders may help ensure a more informed, flexible, and cooperative approach to incorporating generative AI into higher education by identifying and emphasizing core abilities.

Appendix A: Interview Questions

These interview questions were designed to elicit rich, detailed responses from participants about their experiences, perceptions, and challenges related to generative AI adoption and use in their academic work. The questions cover a range of topics, from participants' background and familiarity with generative AI to the specific skills they consider essential, the challenges they have faced in developing these skills, and the impact of generative AI on their learning and academic work. The questions also explore institutional support and integration of generative AI, as well as participants' views on preparing for a future where generative AI is increasingly prevalent.

1. Background Information:
    a. What is your current level of study (undergraduate or postgraduate)?
    b. What is your field of study?
    c. How familiar are you with generative AI technologies?
2. Experiences with Generative AI:
    a. Have you used generative AI tools in your academic work? If yes, which tools have you used?
    b. In what contexts or for what purposes have you used generative AI tools?
    c. How often do you use generative AI tools in your academic work?
    d. Can you describe a specific instance where you used a generative AI tool for an academic task? What was the outcome?
3. Perceptions of Skills Needed for Generative AI Adoption and Use:
    a. What skills do you think are essential for effectively using generative AI tools in your academic work?
    b. Why do you consider these skills to be important?
    c. How have these skills helped you in your interactions with generative AI tools?
    d. Do you think these skills are different from those needed for other types of AI or technology in general? If so, how?
4. Challenges in Developing Generative AI Skills:
    a. What challenges have you faced in developing the skills needed for using generative AI tools effectively?
    b. How have you tried to overcome these challenges?
    c. What resources or support do you think would help you better develop these skills?
    d. Has your institution provided any specific training or resources related to generative AI skills development? If yes, can you describe them?
5. Impact of Generative AI on Learning and Academic Work:
    a. How has the use of generative AI tools influenced your learning process?
    b. In what ways has generative AI impacted the quality of your academic work?
    c. Do you think generative AI has changed the skills that are valued or required in your field of study? If so, how?
    d. How do you see the role of generative AI in your future academic or professional work?
6. Institutional Support and Integration of Generative AI:
    a. How has your institution integrated generative AI into the curriculum or learning activities?
    b. What challenges do you think your institution faces in integrating generative AI effectively?
    c. What additional support or resources do you think your institution should provide to help students develop generative AI skills?
    d. How do you think institutions can better prepare students for a future where generative AI is increasingly prevalent?
7. Closing Questions:
    a. Is there anything else you would like to share about your experiences with generative AI or the skills needed for its effective use?
    b. Do you have any questions for me or any final thoughts on this topic?

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