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# USER-DEFINED DESIGN REQUIREMENTS OF INTELLIGENT TUTORING SYSTEMS: A QUALITATIVE STUDY FROM THE PERSPECTIVE OF HEI LECTURERS IN GHANA

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**ABSTRACT:** *Intelligent Tutoring Systems (ITSs) offer numerous advantages for educators, such as providing personalized and differentiated instruction for diverse learners, which is a key element in shifting from teacher-centred to student-centred pedagogies. ITSs also help reduce teachers' workload related to routine tasks, such as grading, providing feedback, and remediation, while promoting lifelong learning and supporting students' careers. Despite these inherent benefits, developing countries like Ghana have yet to realize the full potential of ITS. A significant gap remains in the contextual adaptation and implementation of ITS within Colleges of Education, as users have little to no input in the development process. Most existing ITSs are designed based on Western pedagogical frameworks, which may not align with the curriculum, language preferences, and infrastructural realities of Ghanaian higher education institutions. This study explores user-defined design requirements for ITS from the perspective of lecturers at Ghanaian Colleges of Education. Using a qualitative research approach, data were collected through semi-structured interviews with fifteen lecturers from three institutions: Offinso, Kibi, and Berekum. The results show that ITS design should align with pedagogical goals, include multilingual and culturally responsive features, support adaptive learning, and integrate seamlessly with existing educational technologies and Learning Management Systems. The implications of these findings for ITS developers, policymakers, and teacher educators are discussed, particularly in relation to the specific needs of higher education in developing countries.*

**KEYWORDS:** Intelligent Tutoring Systems, user-defined design, higher Education, Teacher Education, Qualitative study, Ghana.



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## INTRODUCTION

The integration of Intelligent Tutoring Systems (ITS) into education presents transformative opportunities for personalized instruction. ITS can support differentiated learning, monitor learner progress, and automate feedback, thereby enhancing teaching efficiency. However, these systems often embody the technological and pedagogical assumptions of their creators, which may not be appropriate for contexts such as Ghana. Therefore, it is essential to gather insights from end-users, lecturers at Higher Education Institutions (HEIs), to inform the design of culturally responsive and context-aware ITS. This study concentrates on lecturers from three Ghanaian Colleges of Education to identify key user-defined design requirements for ITS.

ITSs are complex, coordinated programs that apply the standards and strategies of Artificial Intelligence (AI) to the issues and needs of teaching and learning. Intelligent Tutoring Systems ITS are AI-powered platforms that deliver personalized instruction and feedback to learners. They typically consist of a domain model (subject knowledge), a student model (learner profile), a pedagogical model (instructional strategy), and an interface module. They are proposed to help and improve the teaching and learning process in the selected field of knowledge, while respecting the student's independence (Pedrag et al., 2016). These software programs incorporate artificial intelligence techniques to create an effective, personalized educational platform. According to Sottilare et al (2013), every ITS revolves around four basic components for efficient operation. 1. The first model, known as the subject domain which is designed to present and review information with the student, 2. The next component should be geared towards presenting the knowledge that the learner needs to acquire, 3. the student model also which represents the cognitive and metacognitive abilities of the learner, and 4. the tutor domain, acting as the pedagogical basis for lesson delivery. The design and implementation of this system aim to ensure that learners can regulate their learning to achieve higher development. Self-regulation is mostly related to educational goals. It refers to learning that is directed by one’s metacognition (thinking about one's thinking), strategies (planning, monitoring, and evaluating personal progress against a standard), and one’s motivation to acquire knowledge (*Panadero and Ernesto, 2017).* The idea of self-regulated learning is also gaining roots in systems development for educational purposes. Computing education has received greater attention with regard to the design and use of ITS in higher education. Typical among these are: Adil (Automated Debugger in Learning System): used to detect and correct bugs in C programming; if no bugs occur, the program's significance can be explained. Adil is based on the Conceiver's architecture, an automated system of program understanding (Syed et al, 2000). ADIS (Animated Data Structure Intelligent Tutoring System) is a web-based, Java-based, for teaching data structures. ADIS is fully introduced in Java to enable platform-independence, stand-alone, or web distribution (Kai and Tan 1997). DCG (Dynamic Courseware Generation) is an ITS-based intelligent tutoring system (ITS) using AI planning methods to determine instruction content (Vassileva and Ralph 1992). BITS (Bayesian Intelligent Tutoring System) is a Web-based intelligent tutoring system (WITS) for computer programming. The decision-making process carried out in the BITS is controlled by a Bayesian network. (Butz, Hua, and Maguire 2004), natural language processing (NLP) (Liddy, 2001) can function as a chatbot to interact with students, providing feedback and necessary learning interventions (Lin & Mubarok, 2021). Another example involves leveraging the robust data mining capabilities of machine learning to perform learning analytics activities or predict performance (Choi & McClenen, 2020; Ouyang et al., 2023). Additional applications include using image recognition to identify students’ facial expressions, gestures, or emotions to inform


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teachers' future actions (Leony et al., 2013; Singh et al., 2022). AI systems can significantly contribute to sustainable education. AI-powered algorithms can analyze student data to create personalized learning experiences, helping students learn more effectively and efficiently while reducing the time and resources traditionally needed for teaching. Several AI systems can promote sustainable education, such as personalized learning platforms that use AI algorithms to customize educational content for individual students. Furthermore, AI-driven chatbots can respond to student inquiries and offer tailored learning experiences. Another common example is AI-enabled technology, which can be used for performance prediction and real-time monitoring of students' progress to facilitate necessary interventions by instructors. From the educators' standpoint, Intelligent Tutoring Systems (ITS) can serve as valuable tools to improve teaching and learning practices instead of being seen as threats or replacements. ITSs provide several benefits for educators, including delivering individualized and differentiated instruction to diverse learners, a key aspect of shifting from teacher-centered to student-centered teaching (Ogunkunle & Qu, 2020; Silva et al., 2022). Additionally, ITSs can reduce teachers' workload related to routine tasks like grading, providing feedback, and remediation, allowing educators to focus more on the core aspects of teaching (Atapattu & Falkner, 2016; Tobarra et al., 2021). Ultimately, teachers can foster lifelong learning and professional growth, benefiting both students and themselves.

Though all the above-mentioned ITSs are making a significant impact in education in developed countries, their impact and inherent benefits are yet to be felt in developing countries such as Ghana. In developing countries, ITS adoption is often hindered by infrastructural limitations and misalignment with local pedagogical practices. Emphasis had been made on the need for ITS to reflect local languages, teaching styles, and curriculum requirements (Boateng et al., 2020). The proliferating shortage of qualified teachers, especially in developing countries, along with the increasing number of students worldwide, poses a societal threat globally and provides a strong motivation to continue investing in ITS research and solutions to improve and support human learning and development in an accountable way and on a large scale. It is therefore important to investigate ITSs for a variety of other educational activities in more complex domains that can benefit from individualized support, such as learning from examples (Long & Aleven, 2017), learning by exploration or games (Conati & Kardan, 2013; Porayska-Pomsta et al., 2013; Grawemeyer et al., 2017), or learning by teaching (Biswas et al., 2005). For these tools to be effective, it is crucial to understand contextual needs and user-specific requirements for integrating them into education. User-defined design should therefore be central to the design and implementation of these systems. User-centered design (UCD) is essential in most modern software development processes. Its core philosophy states that the needs, abilities, and preferences of the end user should guide every stage of the system design process. User scenarios, personas, and requirements are created, evaluated, and incorporated from the beginning of the system's lifecycle. The information gathered early on informs the development of product features and the overall user experience. As the product design progresses, user testing and feedback help refine these features. The UCD process can be divided into three phases: analysis, development, and post-release. Several methods and tools used in UCD include user surveys, interviews, focus groups, personas, log data analysis, prototyping, and usability testing. (Ian Pitt et al., 2021) The persona lifecycle is a structured set of processes and tools that complement other well-established methods. (Tamara Adlin, 2006) ISO 9241-210 outlines the scope of work for usability and human factors experts supporting UCD. The updated standard emphasizes iteration throughout the entire design process and promotes human-centered methods across the system lifecycle. (Carol, 2021)


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Fundamental principles of UCD include early focus on users and tasks, empirical evaluation of product use, and iterative design. (Kelly, 2015) The first principle stresses the importance of involving users from the beginning and systematically gathering their requirements. This strategy enhances usability and reduces revisions later in development. (Kathy Baxter et al., 2005) The second principle centers on usability testing early in the lifecycle of prototypes, using metrics like errors, assist features, and task completion rates. (Kelly Caine, 2015) The final principle recommends collecting experiential data and continuously refining and testing the product until it fulfills requirements. Iterative design promotes early failure and subsequent modifications to the prototypes' user interface rather than the live system. (Kelly Caine, 2015)

A significant amount of preliminary work is essential for authentic user-centered product design, as it facilitates comprehensive analysis of user requirements and interaction modeling. (Karl Werder et al., 2015) This initial phase ensures a consistent and cohesive user interface and navigation structure, aiding designers to identify suitable concepts from the outset. User research plays a vital role in the upfront design efforts within agile environments. (Karl Werder et al., 2015) Upfront design activities should primarily be viewed as a preliminary exploration, leveraging the potential of UCD to generate innovative ideas. Additionally, a transition from an upfront design paradigm to an upfront analysis approach has been recognized. To deliver a product that is both usable and valuable to customers and end-users, product discovery and creation should be distinctly separated within UCD. (Karl Werder et al., 2015) Overall, substantial initial work is necessary to guarantee the usability and utility of software in agile software development. (Karl Werder et al., 2015)

Despite the growing interest in technology-enhanced education in Ghana, there is a significant gap in the contextual adaptation and implementation of Intelligent Tutoring Systems (ITS) within Colleges of Education, as users have minimal or no input in the development of such systems. Most existing ITS are developed based on Western pedagogical frameworks, which may not align with the curriculum, language preferences, and infrastructural realities of Ghanaian HEIs (Boateng et al, 2020). Consequently, there is limited understanding of how ITS should be designed to effectively serve the needs of lecturers and pre-service teachers in this context. Without input from end-users, ITS solutions risk being ineffective or underutilized. User-centered design (UCD) prioritizes end-user needs in system development. This approach ensures that technologies are intuitive, relevant, and adaptable to specific contextual needs (Norman & Draper, 1986). This study therefore aims to:

1. To explore lecturers' perceptions of the pedagogical roles and functionalities expected of Intelligent Tutoring Systems in Ghanaian Colleges of Education.

2. To identify the contextual design requirements—linguistic, cultural, and infrastructural essential for effective ITS integration in Ghanaian teacher education.

3. To derive user-centred guidelines for the development of ITS tailored to the educational and technological landscape of Ghana's higher education sector.


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## RESEARCH DESIGN

This qualitative study used a phenomenological approach to explore lecturers’ lived experiences and expectations regarding ITS design. The approach provided an in-depth understanding of lecturers’ perspectives within their specific environments. The study was carried out in three public Colleges of Education in Ghana: Offinso College of Education (Ashanti Region), Kibi Presbyterian College of Education (Eastern Region), and Berekum College of Education (Bono Region). These institutions were selected based on their regional diversity and involvement in ICT-in-education initiatives. Fifteen participants were chosen through purposive sampling: five lecturers from each college. Criteria for selection included at least three years of teaching experience and active use of educational technologies in instruction. Data collection involved semi-structured interviews conducted over one semester (1st Semester 2024/25 academic year). The interview guides focused on lecturers’ views about features, functions, and contextual factors related to ITS design. Interviews were recorded and transcribed word-for-word. Data analysis was performed using thematic analysis following Braun and Clarke’s (2006) six-step framework: familiarization with data, initial coding, theme identification, review, definition, and final report. NVivo software supported the coding and theme development.

### Ethical Considerations

Ethical clearance was obtained from a university ethics board. All participants provided informed consent and were assured of confidentiality and anonymity

### Findings

Four major themes emerged from the analysis:

### Pedagogical Alignment

Lecturers emphasized the importance of aligning ITS with the national teacher education curriculum. Many expressed the need for the system to support specific pedagogical competencies outlined in the curriculum, such as lesson planning, teaching strategies, assessment techniques, and reflective teaching. ITS should also simulate classroom situations that allow student-teachers to practice pedagogical decision-making in a risk-free environment.

Quotes from participants emphasized:

"*It should help us teach methodology courses... like how to develop lesson plans and how to use instructional materials,"* (Lecturer, Kibi). "The system must not contradict our syllabus. It should reinforce it and help students prepare for practicum," (Lecturer, Offinso).

### Cultural and Linguistic

Relevance A recurring theme was the need for ITS to be sensitive to the local sociolinguistic context. Lecturers expressed concerns about the dominance of English-only systems, which they argued could disadvantage students with limited proficiency in English. They recommended multilingual options that include local Ghanaian languages, as well as culturally relevant content that resonates with learners' everyday experiences.


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*"If the system could switch between English and Twi, or even display key terms in both, students will understand better,"* (Lecturer, Berekum). "Examples should not always come from foreign countries. Why not include something from Ghanaian culture?" (Lecturer, Kibi).

**Adaptive Learning and Analytics**

Participants highlighted the necessity of incorporating adaptive learning features that respond to individual learner profiles. They envisioned a system that would detect a learner's strengths and weaknesses and then provide differentiated learning pathways. Equally important was the integration of analytics dashboards that allow lecturers to track student engagement, performance trends, and knowledge gaps.

*"Each student learns at a different pace. The ITS should know when a student is struggling and revise the content accordingly," (Lecturer, Offinso). "Analytics would help us know who is doing well and who needs extra help. That is important for intervention,"* (Lecturer, Berekum).

**Usability and Integration**

The final theme addressed the technical and practical considerations for ITS use. Lecturers strongly advocated for systems that are user-friendly, intuitive, and capable of operating under low bandwidth or offline conditions. Additionally, many participants stressed the need for ITS to be integrated with existing digital platforms like Moodle or mobile apps commonly used by institutions.

*"The system must not be too complicated. It should work like the apps we already use, maybe even be mobile-friendly" (Lecturer, Kibi). "We sometimes teach in areas with poor internet. The system should be usable offline,"* (Lecturer, Offinso).

## DISCUSSIONS

The study's findings highlight a strong consensus among lecturers on the importance of tailoring ITS to the pedagogical, cultural, and technological realities of Ghanaian higher education institutions. These insights highlight the limitations of applying generic ITS models developed in Western contexts to African educational settings without proper contextual adaptation.

First, the focus on pedagogical alignment emphasizes the importance of curriculum consistency. In Ghana, Colleges of Education follow a standardized teacher training curriculum designed to equip student-teachers with content knowledge, pedagogical skills, and assessment literacy. ITS that do not align with this structure risk being seen as irrelevant or burdensome. Therefore, ITS developers should work closely with curriculum developers and teachers to incorporate learning content and assessment strategies that support national teacher education objectives.

Second, the call for linguistic and cultural sensitivity exposes broader issues of inclusion and access. English-only ITS may exclude or marginalize learners who speak other languages or have lower proficiency levels. Multilingual support, especially including major Ghanaian languages like Twi, Ewe, and Fante, is crucial for making digital instruction more accessible. Additionally, customizing examples and scenarios within ITS content can boost learner


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engagement by placing knowledge in familiar contexts—an approach backed by culturally responsive pedagogy.

Third, the findings regarding adaptive learning and learner analytics demonstrate the growing need for personalized education in higher education. Adaptive ITS that responds to students' learning habits and provides real-time feedback can greatly improve teaching and learning outcomes. For instructors, analytics tools integrated into ITS can serve as diagnostic resources, enabling timely interventions and better instructional decisions. However, to fully harness this potential, educators need professional development focused on interpreting data and making pedagogical decisions based on learner analytics.

Furthermore, the focus on usability and system integration addresses infrastructural challenges common in developing countries. The preference for systems that operate under low bandwidth or offline conditions reflects a practical understanding of the digital divide. ITS compatible with existing platforms like Moodle and accessible via mobile devices, making it more likely to be adopted and maintained in environments with limited resources. Therefore, user interface design should prioritize simplicity, flexibility, and interoperability.

The study also shows that lecturers are not just passive users of technology but knowledgeable stakeholders with valuable insights. Their involvement in designing and implementing ITS is essential for ensuring relevance to context, user satisfaction, and long-term sustainability. A participatory design approach that empowers lecturers as co-creators rather than just end-users can help bridge the gap between technological capabilities and educational impact. In summary, the discussion emphasizes that successful ITS implementation in Ghana must consider the complex interaction of pedagogical, cultural, and technological factors. These findings have important implications for educational technology policies, system development, and capacity building in higher education institutions.

## CONCLUSION

This study reveals key user-defined requirements for ITS implementation in Ghanaian Colleges of Education. These include curriculum alignment, linguistic localization, adaptive capabilities, and usability under infrastructural constraints. Addressing these factors will ensure that ITS is not only adopted but also effective in supporting teacher education in Ghana.

## RECOMMENDATIONS

- Engage lecturers in co-design processes to tailor ITS features to educational needs.
- Localize content linguistically and culturally to enhance accessibility.
- Align ITS content with Ghana's national teacher education curriculum.
- Provide training programs for lecturers on using the ITS and interpreting analytics.
- Develop ITS with offline functionality and low-data consumption features.


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