Enhancing Student Engagement and Learning Outcomes through AI-Powered Intelligent Tutoring Systems

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Abstract
This study explores how Artificial Intelligence-powered Intelligent Tutoring Systems (ITS) enhance student engagement and learning outcomes in higher education. Grounded in constructivist, socio-cognitive, and self-determination theories, the research adopts a qualitative phenomenological research design. A purposive sample technique of twenty participants from higher education of Punjab was used. Data were collected through semi-structured interviews and analyzed using Braun and Clarke's six-step thematic analysis model to identify recurrent patterns and themes. Findings revealed four dominant themes: (1) personalized and adaptive learning pathways, (2) enhanced motivation and real-time feedback, (3) development of self-regulated learning skills, and (4) promotion of equity and accessibility in education. Collectively, these themes indicate that ITS fosters individualized learning experiences, intrinsic motivation, and learner autonomy, while supporting inclusive and data-driven pedagogical practices. However, concerns about data privacy, algorithmic bias, and institutional readiness remain critical for responsible implementation. The study concludes that ITS represents a transformative pedagogical innovation that aligns with learner-centred educational paradigms. It recommends further research on cross-cultural, longitudinal, and mixed-method investigations to deepen understanding of ITS effectiveness and ethical integration in higher education.
Keywords: Artificial Intelligence, Intelligent Tutoring Systems, Higher Education, Student Engagement, Personalized Learning, Qualitative Research, Adaptive Learning

Introduction
Increased application of artificial intelligence is a paradigm shift in the processes of designing, delivering, and assessing learning. The traditional lecture-based methods do not work in the current environment where social and cultural diversity and globalization of the students are on the rise, and where institutions are fully turning into hybrid and online learning experiences (Holmes et al., 2019). This is why the necessity of adaptive and data-driven pedagogical models that will be capable of personalizing the learning and ensuring constant

assistance is increasing. The most popular of these inventions is Intelligent Tutoring Systems (ITS), which is a type of AI solution that simulates the roles of human tutors, tailors the content to the individual needs of the learners, provides real-time feedback, and mastery-oriented learning (VanLehn, 2011).

ITS impact on tertiary learning is not just a technology innovation. They represent a didactic transformation to teacher-oriented and learner-oriented, and individualized instructional settings (Woolf, 2010). In contrast to traditional e-learning, where the content is static, ITS constantly analyses the behaviour, knowledge gaps and interests of the learners to actively change the teaching. It will help in making the learning process more reactive and personalized, which will suit the needs of the different students and will also make the process as cognitive as it can be.

The demands are enormous: students have lost interest, dropout rates are simply astronomical, a superficial school education and disparity in access to good schooling (du Boulay, 2018; Fredricks et al., 2004). ITS is a solution opportunity because they provide scalable instructions, and they are the ones that can be realized only in small-scale classroom-based instructions in personal tutoring. As has been marked out, one-on-one tutoring can escalate learning to an extent of 2 standard deviations relative to standard classroom instruction, which is also referred to as the 2-sigma problem. ITs are aligned with similar results with the assistance of AI. The issue addressed in the current study is the application of AI-controlled ITS to help students become more engaged and learn in college. It discusses the theoretical underpinnings of what surrounds ITS, how they affect the behaviour and thinking of learners, and the overall pedagogical implications of their use.

Objective of the Study
How do AI-powered Intelligent Tutoring Systems enhance student engagement and improve learning outcomes in higher education?

Literature Review
Using the theories of education, one can possibly clarify the success of ITS in the field of engagement and learning outcomes. Constructivism, the socio-cognitive theory and the self-determination theory (SDT) are the theoretical frameworks upon which this paper is designed.

Constructivism assumes that learners build their knowledge through experiences and interaction in a constructive way and not imposed on them (Piaget & Inhelder, 2008). ITS have implemented this theory through the interactional problem solving, inquiry learning and feedback adaptivism of the learners. These systems, such as AutoTutor, which rely on natural language processing to make crude estimations of Socratic dialogues, help enable students to construct their own knowledge instead of giving an easy answer (Graesser et al., 2005). It is an active form of learning that will lead to a higher level of thinking process and enrichment of memories. Higher order and critical thinking have been focused on in the local and international literature (Jamil et al., 2023; Jamil et al., 2025; Jamil et al., 2024; Jamil & Muhammad, 2019; Liu, 2023; Michael & Ephrem, 2022; Naseer et al., 2022).

The socio-cognitive theory of learning, as introduced by Bandura (1986) focuses on the socio-cognitive nature of learning, such as self-efficacy, feedback as well

and modelling. ITS meets these principles by offering direct instruction, feedback, scaffolding the construction of learners, and modelling professional techniques of problem solving. To demonstrate that, it is possible to schedule the complexity of the work with the help of Carnegie Learning MATHia, which depends on the performance of the student, and this is beneficial to encourage self-efficacy and persistence. The misconceptions are also corrected, and the positive learning behaviours are reinforced, which leads to increased confidence and motivation of students.

In self-determination theory (SDT) (Deci & Ryan, 2000), intrinsic motivation consists of three psychological needs that must be fulfilled, namely autonomy, relatedness and competence. ITS provides these needs by means of granting students control over learning rate (autonomy), giving students tasks they are competent enough to deal with (competence) and, more recently, include features of collaborative (relatedness). These motivation drivers would be associated with systems that possess the elements of peer-learning or adaptive hints, which maintain interest and motivate the learners to proceed with the learning. The history of ITS development has been shown in the development of AI and educational technologies. The initial ITS of the 1970s were rule-based expert systems based on pre-defined instructions. They were only able to work in certain areas such as mathematics and programming (Sleeman & Brown, 1982). In the 1990s, model-tracing and constraint-based systems became possible and could trace student errors and edit instruction according to those errors (Anderson et al., 1995).

In the 21st century, ITS has been presented state of a state-of-the-art system grounded on machine learning, natural language processing and affective computing to provide yet finer, more human-like interactions (VanLehn, 2011). The recent systems such as AutoTutor, Duolingo and ALEKS use predictive analytics to anticipate the needs of the learner, and affective computing is a technology that can be able to identify the emotional state and adjust the instruction to maintain the student interested (Fulmer et al., 2015).

Student engagement is generally known as one of the most important factors of academic success. It is multidimensional, and it consists of behavioural, cognitive and emotional aspects (Fredricks et al., 2004). ITS encourages active engagement, whereby they introduce challenges that are adaptive and gamified to maintain student interest. The systems avoid boredom and frustration, which are significant in disengagement, by adjusting the difficulty of tasks. Adaptive scaffolding and personalized feedback promote more cognitive processing. As an example, higher-order thinking is developed by ITS that requires students to justify their answer or come up with a solution to a complicated question. ITS can be used with intelligent agents that feel empathy, provide motivation, and develop rapport, which enhances the emotional engagement of students in the learning process (Tahir, 2021).

Empirical studies demonstrate that ITS can significantly affect time-on-task, dropout rates, student motivation, and so forth, which is more remarkable than in conventional instruction (Kulik & Fletcher, 2016). In one instance, as the students of Duolingo are motivated to incorporate the lengthy practice sessions, they are motivated by immediate feedback and the indicators of progress. ITS were discovered to be beneficial in students' learning in various areas. According to the meta-analyses, ITS students are equally learning as their counterparts in

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human tutoring and get a lot more compared to those who study in traditional classes (VanLehn, 2011). Additionally, ITS encourage learning students, where students in the mastery level can learn at their own pace and can revisit the information whenever they feel fit, and this will result in retention and transfer.

ITS such as MATHia and ALEKS have enhanced problem solving, conceptual learning and performance improvement in examinations in STEM subjects. Such systems as Duolingo and ELLIS have been used to support the vocabulary, grammar and speaking confidence acquisition in language learning. ITS also enhances self-regulated learning (SRL) besides academic success, which allows the student to plan, monitor and reflect on his or her learning (Winne & Hadwin, 2010).

Research Methodology

The research design was a qualitative with phenomenological research design (Anjum et al., 2021) since the purpose of the study was to explore the perspective of the participants regarding the Intelligent Tutoring System (ITS), which operates on AI to enhance engagement and student learning activity in higher education. This approach was chosen because it gives a chance to examine the multi-faceted social and pedagogical phenomena in detail, pay attention to the lived experiences of the participants, and the meanings they allocate to them (Creswell & Poth, 2018). Purposive sampling was used to select 20 participants; this is a non-probability sampling method that is best suited to qualitative research since the sample is selected based on knowledge and appropriateness to the research question. The semi-structured interviews were conducted among twenty participants of higher education in Punjab. This tool was chosen due to flexibility and the ability to give detailed, reflective answers (Kvale, 1994). Each interview lasted between 30-45 minutes and was conducted using secure video conferencing strategies. Audio-taping of interviews (with the consent of the participants) was done and verbatim transcribed for analysis. Data was analyzed using the thematic analysis, which depends on six steps of Braun and Clarke (2006) model: (1) familiarizing data, (2) finding the initial codes, (3) searching the themes, (4) examining the themes, (5) defining and labelling themes, and (6) creating the report. The motivation behind the choice of this technique is that it is adaptive and orderly in the recognition of patterns and significance in qualitative data. The preliminary stage of coding resulted in over 150 codes which were reduced to bigger categories. There were four dominant themes that were identified through the analysis:

1. Personalized and Adaptive Learning Pathways
2. Enhanced Motivation and Real-Time Feedback
3. Development of Self-Regulated Learning Skills
4. Equity, Inclusion, and Educational Accessibility

Member checking was used to check the reliability of the analysis by involving five participants, and peer debriefing was used to check the consistency of coding with two educational researchers.

Findings of the Study

The thematic analysis revealed four major themes that collectively describe how ITS enhances student engagement and learning outcomes in higher education.

These themes reflect participants' perceptions and experiences and are supported by direct quotations from the interviews.

Personalized and Adaptive Learning Pathways
Among the subthemes that emerged in all the interviews was the fact that ITS could offer a rather personalized learning experience. The interviewees emphasized the significance of individualization that is produced as a result of the continuous examination of the student performance results in the improvement of the engagement and learning outcomes. One of the computer science participants described how the adaptive learning pathways have transformed her teaching process:

Before ITS, I was required to devise a one-size-fits-all syllabus that never fit students with different abilities. The system has now been dynamically adjusted to the content. A low-performing student would be given entry-level modules, and an advanced learner would be given higher tasks. This would result in fewer lost and bored students. The advanced AI algorithms that track the progress of the learners, detect the misconceptions, and adjust the difficulty levels make this customization possible. An example of a platform on cognitive modelling is Carnegie Learning (e.g., MATHia) in which students solve individual problem sets, which are personalized according to their mastery level.

The participants believe that such a customization will not only improve the level of understanding, but also the sense of being the owner of the learning process. When the student is at a level where his or her content is in and competence-wise, the student is likely to develop interest in the content that is being taught. Moreover, adaptive feedback comes in handy to prevent cognitive load and frustration, as one of the biggest barriers to long-term engagement.

Enhanced Motivation and Real-Time Feedback
The second important theme was the role of real-time feedback and encouragement to ensure that the students are kept active. The participants agreed that ITS was one of the affirmative means of providing immediate and first-hand feedback, otherwise absent in the traditional classroom situation. In the view of a participant, it was narrated in the following way:

Students do not have to remain one more week to receive feedback on their grades. ITS tells them immediately whether they are right in their thoughts or they have made a mistake, and how to alter it. This type of feedback will encourage them to do so because they will always be monitored and reminded of the track. This is a kind of response that is fast, contributing to positive learning behaviour and continuity. The respondents discovered that with the presence of ITS, the students were more likely to grapple with the difficult problems, where they were informed that a form of help feedback would be offered to guide them in the correct direction.

In the view of the participants, aspects of motivation, Gamification (badges, progress dashboards and performance analytics) were also motivators. For instance, through systems such as Duolingo or Smart Sparrow, which rely on the logic of a game and thus incorporate an intrinsic motivation of the students and making the whole process of learning a game of reward and competition. These design features are accompanied by the self-determination theory that

identifies the importance of autonomy, competency and accomplishment in the maintenance of motivation (Deci and Ryan, 2000).

Development of Self-Regulated Learning Skills

Some of the themes in the data included the fact that ITS plays a heavy role in self-regulated learning (SRL). It motivates students to participate actively in the process of planning, monitoring, and evaluation of learning. Students may become more independent learners with goal-setting tools, progress indicators and custom-learning analytics. Another participant described it in the following words:

Students who used to take advantage of instructions made by the instructor are now more autonomous. They consult their progress boards, make their learning objectives and go back to the areas where they are experiencing issues. ITS helps in creating a certain metacognitive awareness that would otherwise not be manifested in a traditional classroom context.

In the framework of higher education, SRL is a significant predictor of the academic performance of online and blended classes that form critical predictors of academic performance (Winne and Hadwin, 2013). The inculcating reflection and self-evaluation process presupposes that ITS helps students to acquire transferable learning skills that do not turn into classroom-based based.

In addition to that, the ITS could potentially provide customized learning plans and reactive suggestions depending on the preceding performance, which leads the students to self-directed learning practices. This scaffold helps the students to abandon their learning process as passive consumers of instructions and transform them into active participants.

Equity, Inclusion, and Educational Accessibility

The final theme raised the possibilities of ITS in achieving equity and access to higher education. The participants emphasize that the learning gaps in students with diverse backgrounds, including non-native speakers and first-generation college students, together with students with learning disabilities, should be closed with the help of adaptive technologies. It was explained by another participant in the following words:

ITS can be likened to a safety net to most students, especially those who fail to excel in the normal classroom. It visits them in their place and gives them the time and motivation they need to accomplish.

ITS systems such as AutoTutor and ELLIS have been identified to be effective in helping a diverse range of learners as they offer them pacing and language support. Moreover, cloud based ITS tools make sure that high-quality instructions can be accessible to students who have no location or socioeconomic limitations, which is quite a significant component in the post-pandemic era of remote learning (Holmes et al., 2021). The other statement that the respondents made was that the effects of implicit bias were minimizable using ITS during normal teaching. The ITS will be useful in balancing the learning process as the performance of the students will be quantified, not based on subjective perception, but rather based on the objective. However, as other interviewees asserted, the algorithmic bias issue (which causes biased training data) is among the most significant threats, and the issue will be addressed through strict testing and morals.

Discussion

Each of the results can be interpreted to assume that AI-based ITS has drastic consequences on interaction and student performance in higher education. The mechanisms that are used to bring about the outcomes are personalization, adaptive feedback, self-regulation support and inclusivity. All this combined is making the learning process more interactive and fairer, and productive as compared to the traditional models of learning. Nevertheless, it is also related to the problematic questions, which include the issue of data privacy, the ethical application of AI and the necessity to have a properly developed system of institutional support.

Among the major implications of introducing ITS, there is the possibility of changing the pedagogical emphasis on content delivery to the facilitation of learning. The experiment showed that adaptive algorithms guided by personalized instructions contribute to a higher level of motivation, understanding, and perseverance (Walkington, 2013). ITS solves the historic issue of heterogeneity in the classroom by enhancing learner-specific content according to their level of knowledge and pace of learning. Moreover, ITS helps promote learner autonomy, which is one of the fundamental values of the self-determination theory (Deci & Ryan, 2000).

The autonomy-supportive learning conditions enable the students to control their learning experiences, make decisions regarding their learning directions and even achieve self-directed learning behaviours (Alrabai, 2021). Such empowerment is greater than the improvement of engagement to the point that it equips the student with life-long learning skills, a skill that is necessary in the quickly changing knowledge economy. It does not imply that the implications are confined to individual classrooms. On an institutional level, ITS can facilitate the making of decisions based on data with the details regarding the student progress, learning bottlenecks, and curriculum performance (Gonugunta & Leo, 2024). Universities can create more responsive and evidence-based approaches to education because of this type of analytics (Kuromiya et al., 2020).

Implications for Policy and Practice

ITS can transform not only in the classroom but also in the strategies and policies of the institution-wide, but as the national education policy. Governments and accreditation agencies should consider how adaptive learning technologies would facilitate the quality assurance standards, equity objectives, and workforce readiness programs. The AI features in education, with the policy structures that facilitate research and innovation, and a sense of ethical governance, should be considered without interfering with the capability of all the institutions to utilize the technology, even those with the lowest number of resources.

The practitioner-level teachers should be sensitized to the use and application of ITS and how they can be incorporated into pedagogy. The most successful ones are the ones where ITS are not isolated tools, but also components of a larger learning ecosystem- supplementary to lectures, group projects, and learning experiences.

Conclusion

Intelligent Tutoring Systems is an effort to apply the advantages of AI in the context of higher education to offer a scalable, personalized, and flexible solution to one of the most intractable challenges in higher education. ITS introduces a significant degree of improvement in the performance of the students in terms of interaction and learning since the learning is tailored to the needs of the students, which gives them instant feedback, enabling them to learn independently, and it is more accessible. They reflect the shift towards learner-centred ecosystems from teacher-centred teaching, which agrees with constructivist, socio-cognitive, as well as self-determination theories.

Nonetheless, the integration of ITS is not an easy task due to the complexities. The issue of data privacy, bias in activities of algorithms, ethical responsibility and institutional readiness should be addressed in such a way that their application would enhance the equity and integrity of education and not damage it. It is assumed that the future of higher education will be defined by the interaction of the institutions to take the power of AI in responsible ways, and a balance between technological innovation and the fact that the human component of teaching and learning may not be replaced. ITS are not only technological innovations, but also a catalyst for a larger pedagogical change, where the learner will be at the centre, active participants in their learning process, and where the learner will now have the skills and experience, they will need once they get to the knowledge-driven and rapidly shifting world.

Future Research Directions

Future research should address the following areas:

- Longitudinal impact studies may be conducted to identify the longitudinal effects of engagement with ITS on engagement, retention and career outcomes.
- Cross-cultural and cross-disciplinary studies may be conducted on the success and acceptance of ITS using the cultural standard, language and interdisciplinary differences.
- Ethical regimes and policies should be designed regarding how to design generic principles of data governance, AI transparency and responsible use of AI in education.
- Human-artificial intelligence collaboration models should be merged with human instruction, and the role that instructors play in AI-enhanced learning settings can be re-imagined.

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