

The Development of an AI-Based Adaptive Learning Environment to Enhance Student Engagement in ESP Classroom: A Preliminary Study

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ABSTRACT

Student engagement in higher education is a key factor in their academic success. Student engagement can be enhanced through adaptive, interactive learning by integrating AI-powered tools. These AI-powered tools offer interactive and adaptive learning experiences through personalized learning content and specific feedback tailored to individual student needs. This research is particularly relevant in the modern 21st-century learning context, emphasizing personalized learning to increase student engagement in the educational process. Therefore, this research aims to investigate an AI-based adaptive learning environment to enhance student engagement in ESP learning. To measure student engagement, a modified University Student Engagement Inventory (USEI) was employed to collect data on student engagement. There were 62 responses collected. The result of the study showed high Behavioral Engagement, moderate Cognitive Engagement, and low Emotional Engagement. It can be concluded that the students are emotionally detached, lacking enthusiasm, and perceive personal value in the learning process. A personalized and adaptable learning environment is needed to improve the learning engagement in a classroom with diverse backgrounds.

Keywords: *student engagement; English for Specific Purposes; Artificial Intelligence; AI-powered tools; personalized learning.*

1) INTRODUCTION

Entering the era of Industry 4.0 and Society 5.0, the global higher education landscape is undergoing a fundamental transformation. Higher education institutions no longer function merely as conveyors of knowledge, but also as primary facilitators in developing competencies relevant to the demands of the 21st-century. In this interconnected global context, English proficiency has evolved from a mere supplementary skill into a core competency. English serves as the lingua franca in the realms of science, technology, academia, and international trade. Therefore, the success of higher education programs in equipping students with capable English skills, particularly in English for

Specific Purposes (ESP), has become a critical determinant of graduate competitiveness in the global job market.

However, the achievement of this proficiency often faces various pedagogical challenges. One of the most significant internal factors determining a student's academic success is student engagement. Student engagement has been identified by researchers as a "panacea" for learning; actively engaged students demonstrate higher persistence, better academic achievement, and a more profound level of satisfaction with their learning experience. Engagement is not a monolithic concept; it is a complex multidimensional construct. Referring to the fundamental framework, student engagement can be sorted into three interrelated dimensions: behavioral, cognitive, and emotional (affective) engagement (Fredricks, Blumenfeld, and Paris, 2004; Dharmajaya et al., 2012; Maroco et al., 2016; Assuncao et al., 2020; She et al., 2023).

Behavioral engagement is the most easily observable dimension. It includes tangible participation in the classroom, adherence to academic rules, attendance, and the timely submission of assignments. Cognitive engagement, on the other hand, is more internal. It refers to the student's psychological investment in learning, such as the willingness to exert effort to understand complex material, the use of deep learning strategies, and self-reflection on the learning process. The third dimension, and perhaps the most crucial yet most often overlooked, is emotional engagement. This dimension encompasses the student's affective reactions to the learning process, lecturers, peers, and the institution. It manifests as a sense of enthusiasm, interest in the material, a sense of belonging to the learning community, and the perceived value of the assigned tasks. (Maroco et al., 2016; Dharmayana et al., 2012; Sa'adah & Ariati, 2018; Jamaluddin et al., 2022; Pratama & Guspa, 2022).

The challenge of fostering these three dimensions becomes increasingly complex in the context of English for Specific Purposes (ESP) learning. Unlike General English (GE), which focuses on everyday language skills, ESP is designed to meet the highly specific language needs of a particular field of study or profession. In the context of this research, students come from highly diverse study programs, such as Informatics (TI) and Visual Communication Design (DKV). TI students require English to read technical documentation, write code, and collaborate on software projects, while DKV students need English to present creative portfolios, communicate with international clients, and understand design terminology.

Traditional ESP learning in this context often defaults to a "one-size-fits-all" approach in which the teacher provides the same learning resources to all students with diverse backgrounds. A traditional classroom might be suitable for particular environments, yet it lacks in providing a personalized learning experience. The adaptive learning environment makes similar learning objectives achievable even though the learning experiences are personalized. The adaptive learning can be customized according to the students' backgrounds. The same instructions in the ESP classroom will not slow down the advanced learners or overwhelm the slow learners. (Tan, et al., 2024). In practice, students from various disciplines and educational backgrounds (e.g., SMA and SMK) are often grouped in the same classroom and taught using the same module or textbook due to many reasons. This irrelevant and impersonal method becomes the root of the problem of low engagement. Students may be physically present (behavioral engagement), but they fail to find the material's relevance to their career paths, which ultimately triggers boredom, a lack of enthusiasm, and cognitive dissonance. This creates what is known as an "affective gap" in which students are procedurally compliant but not emotionally connected to what they are learning.

In response to this challenge, the integration of educational technology (EdTech), particularly Artificial Intelligence (AI), offers a transformative solution. AI in education is shifting from being merely an auxiliary tool to an intelligent facilitator capable of creating entirely new learning experiences. Aligned with the focus of this research, the greatest potential of AI lies in its ability to realize two key pedagogical concepts: personalized learning and adaptive learning. Personalized learning adjusts what (the content) students learn based on their interests and goals, while adaptive learning adjusts how (the path and difficulty) material is presented based on their performance and understanding in real-time. (Tan et al., 2024).

In the ESP context, an AI-based adaptive learning system can theoretically bridge the existing gap. Such a system could diagnose a student's specific needs (e.g., identifying a student as "TI-SMA" or "DKV-SMK") and automatically present a unique learning path. TI students could be given reading materials on machine learning, while DKV students receive case studies on global branding. More importantly, the AI system can directly target the "affective gap." Through feedback that is instant, supportive, and non-judgmental, as well as interactive or gamified elements, the system can enhance enthusiasm and reduce frustration. By dynamically adjusting the difficulty level, it ensures that students

remain within their "Zone of Proximal Development" (ZPD)—sufficiently challenged to stay engaged, but not so difficult as to cause despair. (Tan et al., 2024)

Although much literature has discussed the theoretical benefits of AI for personalization, or separately analyzed student engagement in ESP, a significant research gap remains. Specifically, there is a lack of Research and Development (R&D) studies that systematically design, build, and test an AI-based adaptive learning system explicitly aimed at enhancing student engagement (especially the emotional dimension) within the context of ESP in Indonesian higher education. Many existing studies are evaluative of pre-existing tools, rather than development from scratch based on an in-depth needs analysis.

This article specifically focuses on the findings from the "Analyze" phase. This crucial initial phase is designed to do two things: (1) Analyze the characteristic profiles of participants (potential users) to identify heterogeneity and specific design needs; and (2) Quantitatively measure the baseline (initial condition) of student engagement to validate the problem and identify the primary existing gaps. The findings from this preliminary research are critical, as the results of this needs analysis will become the evidence-based foundation for the entire design and development cycle of the proposed AI system. This paper will present a quantitative analysis of the participant profiles and University Student Engagement Inventory (USEI) scores, which are then used to formulate specific design implications for the subsequent R&D phases. (Maroco et al., 2016; Sinval et al., 2018; Assuncao et al., 2020; She et al., 2023).

2) METHODS

Participants

The participants in this study consisted of 58 students from various study programs at Bhinneka Nusantara Malang University. The majority of participants came from S1 Informatics (IF) with a proportion of 62.07%, followed by S1 Visual Communication Design (VCD) students at 22.41%. Additionally, there was participation from D3 Information Systems (IS) students at 10.34% and S1 Information Systems at 5.17%. This composition shows that the majority of participants have technology and design-based academic backgrounds, which is relevant to the English for Specific Purposes (ESP) learning context developed in this research. In terms of gender, the participants were

dominated by males, with a percentage of 87.93%, while females accounted for 12.07%. Viewed from their educational background before entering higher education, the majority of students graduated from SMA (Senior High School) with a proportion of 46.55% and SMK (Vocational High School) at 43.10%.

The remainder came from the "others" category at 10.34%. This diversity in educational backgrounds provides an overview of the heterogeneity of students' initial abilities in following ESP learning. In terms of age, the majority of participants were in the 20–22-year range (70.69%), followed by the 23–25-year age group (22.41%). Furthermore, 1.72% of participants were aged 17–19 years, and 5.17% were in the 26–28-year age group. This data indicates that most participants are at the typical age of second to third-year students. The classification by study level shows that 37.93% of students were in their 2nd year, followed by 24.14% in their 3rd year, and the 4th and 5th-year groups at 18.97% each. This distribution indicates that most participants already have sufficient academic experience to follow ESP learning, which requires analytical thinking skills, an understanding of professional contexts, and active interaction in the artificial intelligence technology-based learning process.

Questionnaire development

This study was a questionnaire-based study by adapting the University Student Engagement Inventory (USEI) questionnaire which was developed by Maroco (2016). This questionnaire consists of questions related to demographics in Section 1, 15 USEI items in Section 2, and miscellaneous questions in Section 3. The 15 USEI items are rated on a response scale from '1-never' to '5-always'. The focus group in this study consisted of 58 students from the Faculty of SAINTeK (Science and Technology) and the Faculty of EKRAF (Creative Economy), who voluntarily participated in a focus group session held in the English for Specific Purposes (ESP) class.

Procedure

Participants were determined based on ESP classes. Each participant agreed to informed consent, stating that participation in this study was voluntary and that no personal information would be used outside of this research. This study is purely academic for investigating the students' engagement prior to the implementation of Artificial Intelligence (AI) in the classroom. Participants were also assured that the data would only be presented in statistical analysis. No incentive was given for this

participation. Data were collected via an online questionnaire, consisting of demographic questions and the USEI items, during the first semester of the 2025–2026 academic year (February to August 2025).

Data Analysis Technique

The data analysis in this preliminary research uses a descriptive quantitative approach. The focus of this analysis is to validate the needs (needs analysis), which will serve as the foundation for the instructional design in which AI will be employed, aligning with the Analyze Phase of the ADDIE R&D model.

To map the participant profiles, the analysis technique used is frequency and percentage analysis on the demographic data (study program, age, educational background, etc.) from 58 valid respondents. Meanwhile, to identify learning gaps, descriptive statistical analysis (including Mean, Minimum Score, and Maximum Score) was applied to the data from the 15-item University Student Engagement Inventory (USEI). This analysis was used to measure the baseline scores across the three dimensions of engagement: Behavioral, Cognitive, and Emotional.

3) RESULTS AND DISCUSSION

Data analysis was conducted on 58 valid respondents. The demographic profile of the 58 research participants shows sample characteristics that are diverse yet relevant to the research focus. This analysis aims to map the participant profiles and measure the level of student engagement as a baseline before implementing the learning intervention. The analysis of the baseline USEI data (N=58) reveals the central finding of this preliminary research. There is a clear hierarchy in the average student engagement scores, as shown in Table 1.

Table 1: *Baseline Mean Scores of USEI (N=58)*

No.	Engagement Scale	Meaning
1	Behavioral Engagement	Very High
2	Cognitive Engagement	Fairly High
3	Emotional Engagement	Low

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This finding identifies an affective gap as the primary problem. The very high Behavioral Engagement indicates that students are highly compliant procedurally (such as attending, submitting assignments). However, the Emotional Engagement is the lowest. This indicates that although students are compliant, they do not feel emotionally connected, enthusiastic, or perceive personal value in their current ESP learning process.

a. Descriptive Analysis of Participant Profiles

In terms of the significance of study program and educational background, the sample was dominated by students from S1 Visual Communication Design (55.17%) and S1 Informatics Engineering (41.38%). This composition is highly relevant to the context of English for Specific Purposes (ESP), as these two study programs have highly specific and different English language needs; IE focuses on technical language, documentation, and development, while VCD focuses on client communication, creative presentations, and design terminology.

Furthermore, the heterogeneity of the participants' educational backgrounds, divided between SMA (Senior High School) (62.07%) and SMK (Vocational High School) (36.21%), indicates potential diversity in prior knowledge and English proficiency. Vocational High School graduates may have had initial exposure to technical terms, while Senior High School graduates may have a more general grammatical foundation. This diversity reinforces the urgency of the research: a traditional one-size-fits-all learning system will not be adequate. This provides a strong justification for the development of adaptive learning that can adjust materials and difficulty based on the unique needs of these different backgrounds.

Significance of Study Level and Age shows that the majority of participants were in the productive student age range of 20-22 years (75.86%), and were evenly distributed between Level 2 (37.93%) and Level 3 (37.93%). This is an important finding. The participants are no longer new students who are adapting, but rather students in the middle phase of their studies. At this stage, ESP material becomes crucial as they begin to apply English specifically to vocational courses and in preparation for internships or careers. They are also a group of digital natives who are expected to have adequate digital literacy to interact effectively with an AI-based learning system.

The gender composition of the participants was relatively balanced, with males (56.90%) and females (43.10%). This distribution is representative of the fields of technology and design and allows for analysis to identify whether the AI intervention has a different impact across genders.

b. Analysis of Student Engagement (USEI)

The baseline measurement of student engagement was conducted using the 15-item University Student Engagement Inventory (USEI), which is divided into three dimensions: Behavioral, Emotional, and Cognitive. Scores were measured on a Likert scale from 1 (Never) to 5 (Always).

Table 2: *Descriptive Statistics of USEI Scores (N=58)*

Engagement Scale	Number of Items	Average Score (Mean)	Average Score per Item (out of 5)	Minimum Score (Min)	Maximum Score (Max)
Behavioral Engagement	5	21,03	4,21	13	25
Emotional Engagement	5	16,34	3,27	7	24
Cognitive Engagement	5	19,16	3,83	12	25
Total USEI (Overall)	15	56,53	3,77	35	73

The overall mean USEI score (Mean = 3.77 out of 5) indicates a "fairly good" level of engagement. However, a more in-depth analysis of the three sub-scales reveals findings that are crucial for this study. A clear hierarchy exists in the engagement scores:

$$\text{Behavioral (4.21)} > \text{Cognitive (3.83)} > \text{Emotional (3.27)}$$

According to the key findings, it can be interpreted that high behavioral engagement was proven by the per-item mean score of 4.21 (approaching "Frequently"). It means that the participants demonstrate a high level of procedural compliance. They attend class, follow rules, and submit assignments on time. This is an observable form of engagement and is often the main focus in traditional educational systems. However, this high score might be an indication of "compliant engagement" rather than "deep engagement."

The low emotional engagement is the most significant finding from the baseline analysis. With a per-item mean score of 3.27 (slightly above "Sometimes"), Emotional Engagement is the weakest dimension. This indicates a substantial "affective gap." Students may feel less enthusiastic, lack a "sense of belonging" to the ESP class, or fail to find personal value in the learning process. They might view ESP as a mandatory, dry course that is less relevant to their personal interests, even though they remain behaviorally compliant.

Cognitive engagement is moderate. The 3.83 score indicates that students "quite often" use learning strategies, strive to understand the material deeply, and connect it with other knowledge. This score is higher than emotional engagement, showing that they are striving for academic success, but have not yet reached an optimal level of cognitive processing.

c. Implications and Justification for the Research

These findings provide a strong empirical justification for the proposed intervention. The main problem identified is not a lack of compliance (high Behavioral), but rather a lack of emotional attachment (low Emotional). Traditional ESP learning may succeed in making students complete tasks, but it fails to make them care about or take an interest in the material.

This is where the crucial role of AI-based adaptive learning lies. The proposed system aims to bridge this affective gap by:

- **Personalization:** Presenting content (e.g., technical articles for IE, design case studies for VCD) that is directly relevant to their interests and career needs, thereby increasing perceived value.
- **Interactivity:** Transforming passive learning into active participation through instant feedback and interactive elements that can boost enthusiasm.
- **Adaptivity:** Adjusting the difficulty level to address the heterogeneity of backgrounds (SMA/SMK), reducing frustration, and building a sense of competence (success).

Collectively, these initial data analysis results provide an evidence-based foundation for this R&D research. The participant profile analysis justifies the need for a system that is Adaptive and Personalized. Meanwhile, the USEI gap analysis determines the focus of that system: the AI intervention to be developed must be specifically designed to enhance Emotional Engagement, rather than merely training compliance (behavioral) or cognitive skills. Moreover, this study also revealed significant issues with the use of AI-adaptive learning in the real ESP classroom for enhancing

students' engagement, particularly in terms of emotional engagement. Emotional engagement plays an important role in improving students' performance, in addition to cognitive and behavioral engagement. Emotional engagement is not merely important for enhancing the sense of belonging and value towards the lessons, but it also relates to the students' motivation and psychological aspects. Overall, the three dimensions of student engagement improve the students' academic resilience during their studies in higher education. A better emotional engagement leads to an improved psychological aspect of the students, which helps them cope with the higher education challenges. (Annisanian & Nursanti, 2023).

In summary, the "Analyze" phase has provided a clear, data-driven mandate for this R&D project. The findings of participant heterogeneity (A) and a significant affective gap (B) are not just observations; they are the core design specifications. They confirm that the proposed AI system must be engineered not just as a content-delivery tool, but as an engagement-centric environment, prioritized to foster the emotional connection currently missing in the students' ESP learning journey.

4) CONCLUSIONS

This preliminary research has provided a crucial empirical foundation for the proposed Research and Development (R&D) of an AI-based adaptive learning system for ESP. The study completed the "Analyze" phase of the ADDIE model, yielding two critical findings that validate the necessity and define the focus of the subsequent development.

First, the baseline analysis of student engagement (N=58) quantitatively confirmed the primary pedagogical problem: a significant "affective gap" in ESP learning. The data revealed a clear hierarchy of engagement, with high procedural compliance (Behavioral Engagement, Mean = 4.21) but substantially lower emotional connection (Emotional Engagement, Mean=3.27). This finding demonstrates that while students are behaviorally compliant, they are emotionally detached, lacking enthusiasm, and a perceived personal value in the learning process.

Second, the participant profile analysis confirmed high heterogeneity within the target audience, specifically in their study programs (Informatics Engineering vs. Visual Communication Design) and educational backgrounds (Senior High School vs. Vocational High School). This diversity provides a

strong empirical justification that a traditional "one-size-fits-all" pedagogical approach is inadequate, validating the need for a system capable of personalization and adaptivity.

The primary contribution of this paper is the data-driven justification for the proposed technological intervention. By moving beyond anecdotal evidence, we have quantitatively identified that the core problem to be solved is not a lack of student compliance but a failure of current methods to foster emotional engagement.

This implies that the design priorities for the proposed AI system must shift from mere content delivery (which targets cognitive/behavioral aspects) to bridging the identified affective gap. The subsequent Design and Develop phases of our R&D will, therefore, prioritize features—such as personalized content pathways relevant to career interests and interactive, gamified feedback—that are specifically engineered to foster emotional connection and perceived value.

As a preliminary study, this analysis is limited by its cross-sectional nature and reliance on self-reported data from a single institution. Future work, which will be the focus of the complete research, involves the full R&D cycle: the Design, Develop, Implement, and Evaluate phases. The final evaluation will employ a quasi-experimental design (pre-test/post-test) to measure the effectiveness of the developed AI system in significantly enhancing student engagement, particularly in closing the affective gap identified in this foundational study.

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