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Student Academic Writing Analysis for AI-Based Adaptive Learning System Development, Case Study: Building Engineering Education Students

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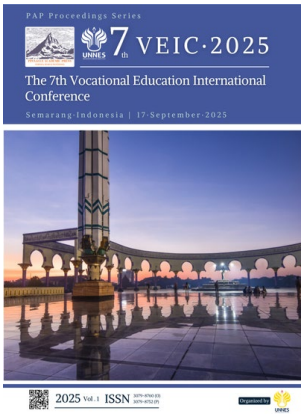

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Abstract: The advancement of Artificial Intelligence (AI) technology in higher education has been suboptimal in tackling the challenges of student academic writing, as current systems primarily concentrate on technical enhancements and have yet to effectively aid students in formulating logical arguments and coherently organizing ideas. This research seeks to evaluate students' academic writing abilities to inform the development of an AI-driven learning system tailored to their specific requirements. A descriptive quantitative methodology was employed to gather data via online questionnaires from 50 students enrolled in the Building Engineering Education Study Program. The instruments were predicated on five dimensions: writing structure, language proficiency, argumentation and logic, reference utilization, and technical writing skills, utilizing a 1-5 Likert scale. The findings indicate that PTB students fall within the "Very Capable" classification, attaining an average score of 82%. The utilization of references garnered the greatest score at 87%, although writing structure and logical argumentation remain at the lowest level, scoring 79%. The findings reveal difficulties in shifting from descriptive technical writing to argumentative academic discourse, underscoring the necessity for an AI-driven learning system that incorporates a corpus-based instructional method to deliver comprehensive feedback on the formation of coherent argumentation structures. The study advocates for the creation of a comprehensive AI system prototype and its extension to other engineering programs to enhance the academic literacy of students across the nation.

Keywords: academic writing; artificial intelligence; higher education

1. Introduction

The realm of higher education has experienced substantial transformations due to technological progress in the Society 5.0 period, which prioritizes human-centric innovation and utilizes technology to improve sustainability, social responsibility, and quality of life. This shift not only altered teaching methodologies but also stimulated the development of more adaptable and technology-integrated pedagogical approaches [1,2]. Artificial intelligence possesses exceptional capacities to enhance the quality and

efficiency of learning processes and has emerged as a significant educational breakthrough [3]. This technology enables the customization of learning systems to meet individual needs, facilitates quicker responses, and promotes optimal learning outcomes through instruction suited to diverse learning styles [4].

The application of AI in academic development encompasses various functions, including learning analytics, the creation of virtual tutors, and automated grading systems for academic materials [5]. Artificial intelligence, beyond being a mere technical instrument, plays a substantial role in enhancing pupils' academic literacy skills. This is particularly pertinent for cultivating critical thinking, formulating systematic arguments, and composing scientific publications that adhere to international standards [6]. Artificial intelligence can deliver automatic, positive feedback by processing information objectively and expeditiously. This will ultimately assist students in cultivating better organized and academically rigorous writing [7].

Obstacles in Academic Writing Proficiency: Despite the plethora of artificial intelligence tools accessible to students, the majority encounter difficulties in formulating coherent arguments, systematically organizing ideas, and conforming to established academic writing conventions [8]. Consequently, hardly 16% of students from underdeveloped nations effectively publish their scientific research in Scopus-indexed international publications.

In asserts that linguistic challenges are the primary reason for the decrease in publications. A further reason for this decline is the incapacity to compose academically, coupled with insufficient direction in formulating methodical and persuasive arguments. Non-native English-speaking international students frequently encounter challenges in composing papers and PhD dissertations [9]. This deficiency undermines the quality of scientific articles and diminishes students' competitiveness within the global academic arena.

This pertains to Sustainable Development Goal (SDG) 4, Quality Education, which underscores the necessity of enhancing academic literacy to guarantee equitable access to quality education for all. SDG objective 4.6 mandates that by 2030, all adults and youth shall attain literacy and numeracy, while in 2024, an estimated 754 million adults globally remain illiterate.

Digital literacy and digital skills are essential for attaining SDG 4, since digital literacy is vital for realizing equitable and quality education objectives in the digital era. Contemporary assistive devices mostly address superficial corrections, such spelling and grammatical inaccuracies, although they fail to provide comprehensive guidance on argumentative clarity and the architecture of academic discourse [10,11].

Despite India's initiation of the One Nation One Subscription (ONOS) program on January 1, 2025, aimed at ensuring equitable access to knowledge for all residents, numerous colleges have been pursuing technology to enhance students' writing skills [12,13]. Nonetheless, a genuinely comprehensive method for instructing individuals on critical thinking, writing structure, and constructing robust arguments in scientific writing is lacking [14,15].

Recent studies indicate that while colleges are beginning to include generative AI in pedagogy and research, there remains a necessity for more organized support. The majority of systems continue to emphasize technical correctors [16]. They have yet to incorporate the conceptual dimension or the logic of reasoning in their work [17]. In research involving 255 individuals from 49 nations participating in 65 international PhD programs indicates that explicit teaching in academic writing in English and customized support are essential. The lack of comprehensive writing tools hinders pupils' comprehension of the logical progression of writing.

Consequently, both the volume and caliber of scientific publications are deficient. Inadequate academic writing abilities impede students' productivity in producing scientific works and obstruct their engagement in global information exchange. 2025 is anticipated to be a year marked by the emergence of numerous well planned

advancements. Effective system design will create new opportunities and methodologies for many scientific disciplines and academic institutions [18].

Consequently, it is essential to develop novel artificial intelligence technologies to assist students in enhancing their cognitive processes and structuring their writing more effectively, so improving the overall quality of their written work. The shift from the traditional education system to the modern one necessitates increased focus on the human element, rather than solely on technology. This entails the integration of emotional intelligence (EQ) and intelligence quotient (IQ). The necessary system must be a learning platform capable of analyzing writing structure, identifying logical links between paragraphs, and offering enhancement recommendations based on the principles of effective scientific writing.

This study is to evaluate students' academic writing abilities to confirm that the created AI learning system architecture effectively addresses real-world requirements. To satisfy the requirements of the future workforce, recent graduates necessitate both academic and practical training. This research aims to enhance the human-centered advancement of educational technology in accordance with the Society 5.0 paradigm [19-23].

2. Methods

This study employs a descriptive quantitative approach with data collection techniques using closed questionnaires distributed online via Google Forms. The selection of this method is intended to obtain an empirical overview of students' skills in academic writing, particularly their ability to construct arguments and build a systematic writing structure. The research instrument was designed based on five main aspects, namely: (1) writing structure, (2) language proficiency, (3) strength of argumentation and logic, (4) utilization of references, and (5) technical writing skills. Each question item uses a 1-5 Likert scale, where a score of 1 represents disagreement or the lowest ability, while a score of 5 indicates the highest level of agreement or ability. The distribution of the questionnaire was focused on final-year students who were taking their thesis course or were in the process of writing their thesis, ensuring that the data obtained was more relevant to the research context.

2.1. Data Participation

The research focus is a group of students from the Building Engineering Education study program at UPI, consisting of 50 people. These students are at a crucial phase in their education, namely completing their final project or thesis required to obtain a bachelor's degree. The students selected as subjects for this research are representative of the final-year student population who have taken various building engineering courses. They are currently using all the knowledge and abilities they gained during their studies to conduct thorough scientific research. This population selection is considered appropriate because students working on their final projects or theses have acquired a deep understanding of the theoretical and practical concepts of building engineering education. Thus, this population can provide relevant and high-quality data and information to support the researcher's research objectives.

2.2. Data Analysis

The research steps include developing a questionnaire instrument in the form of statements with answer choices, data collection, data tabulation and scoring, result interpretation, and quantitative analysis thru the calculation of percentages, mean values, highest and lowest scores [24]. Each indicator was analyzed based on the respondents' level of achievement regarding the measured aspect, according to, as shown in Table 1.

Table 1. Percentage of Student Ability Categories.

No	Category	Percentage (%)
1	Very capable	80-100
2	Capable	60-79
3	Moderately Capable	40-59
4	Less Capable	20-39
5	Not Capable	0-19

To enhance data validity, this study employs triangulation as a verification method. This is because triangulation is understood as an analytical approach that combines data from various sources with the aim of testing consistency and strengthening the interpretation of findings. Thus, the conclusions obtained are expected to have a strong foundation and be scientifically accountable. Next, the results of the instrument validity test are shown thru five main aspects of writing skills assessment. First, the writing structure aspect consists of five statement items (1–5) with an r-value of 0.3598, which is considered valid. Second, the academic language proficiency aspect includes four items (6–10) and is also considered valid. Third, the argumentation and logic aspect, consisting of five items (11–15), shows valid results. Fourth, the use of references aspect with five items (16–20) is considered valid. Finally, the technical writing skills aspect, which includes five items (21–25), also yields valid results. Therefore, all the instruments used can be said to meet the validity criteria. In addition, the instrument's reliability test was conducted using the Cronbach's Alpha (α) value, which was obtained as 0.933. Based on these results, this figure indicates a very good category, so the research instrument is considered reliable and can be used consistently in measuring students' writing skills.

3. Results and Discussion

Prior to delineating the principal conclusions of this study, it is imperative to describe the demographic features of the respondents. This information is essential for establishing initial context for the analyzed data and for identifying patterns and variances in the academic writing abilities of the students participating in this study.

3.1. Respondent Features

An essential aspect of this study involves examining the gender characteristics of the respondents. This analysis provides a demographic overview of the sample and is crucial for contextualizing the findings related to students' academic writing abilities. Numerous prior investigations indicate potential variations in learning approaches, communication styles, cognitive strategies, and patterns of literacy skill development between male and female students in the context of academic writing. This demographic characterization will enhance our understanding of the variations in learning experiences.

Figure 1 illustrates the demographic breakdown of the study: among the 50 respondents, women constitute 70% (35 individuals), while men account for 30% (15 individuals). This suggests a favorable change in gender representation within engineering education, a domain that has traditionally been male-dominated.

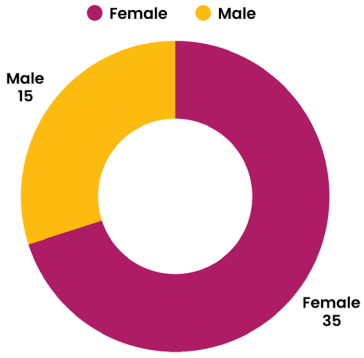

Figure 1. Data Distribution by Respondent Gender.

This observation corresponds with the worldwide trend indicating that women are progressively participating in STEM fields. Despite structural challenges, recent findings indicate that women's participation in the scientific world, including engineering, continues to increase [25]. Data from UNESCO in 2024 indicates that, while women constitute merely 35% of STEM graduates and 22% of the STEM workforce in G20 nations, there are encouraging trends emerging in certain regions.

This study highlights that the relatively balanced gender distribution holds significance that extends beyond mere statistical representation. The majority of women in the study sample possess the ability to enhance the dynamics of academic writing practices by providing wider perspectives and methodologies [26,27]. Recent investigations conducted by employed BERT-based textual sentiment analysis on a dataset of 9,820 articles spanning 87 years, uncovering differences in academic writing styles attributed to gender. Women often adopt a more cautious yet thorough method when formulating academic arguments. The findings highlight the significance of recognizing the various ways academic writing can differ across diverse gender backgrounds enhancement of the standards in scholarly investigation:

The equitable gender representation in this study significantly enhances the validity and depth of the analysis. Recent findings in academic writing indicate that gender diversity can result in differences in writing strategies, argumentative methods, and self-revision practices [28.29]. The balanced gender proportion observed in this study reflects the beneficial effects of diverse initiatives and policy programs aimed at promoting women's involvement in both academic and professional spheres.

According to the STEM Women 2024 whitepaper, over 50% of respondents from 2019 to 2023 indicated that the presence of gender balance within a company would impact their choice to accept a job offer [30]. This finding suggests that students and graduates possess a significant understanding and awareness of diversity and inclusion when evaluating potential employers [31,32].

3.2. Academic Writing Skills of Building Engineering Education Study Program Students

The investigation into the academic writing abilities of students in the Building Engineering Education Study Program is a comprehensive examination of engineering education, whereby the integration of pedagogical skills and technical proficiency is a distinctive attribute. PTB, as an academic program in construction science, provides a distinctive viewpoint on the transition from explanatory technical communication to argumentative and reflective academic discourse.

Based on Table 2, the analysis results of students' academic writing ability show variations in achievement across the five evaluated aspects. The aspect of Reference Use scored the highest with an average value of 4.3 and a percentage of 87%, indicating students' good ability to integrate scientific sources into their academic writing. The Technical Writing Skills aspect ranked second with an average value of 4.2 and a

percentage of 83%, reflecting students' strength in applying technical writing conventions. The Language Mastery aspect came in third with an average value of 4.1 and a percentage of 82%, demonstrating adequate language proficiency.

Table 2. Results of Analysis of Students' Academic Writing Ability.

Aspect	$\bar{x}$	SD	Percentage
Writing Structure	3.9	2.58	79%
Language Mastery	4.1	2.47	82%
Argumentation and logic	4.	2.42	79%
Use of References	4.3	3.10	87%
Technical Writing Skills	4.2	3.07	83%
$\bar{x}$			**82%**

Meanwhile, the Writing Structure and Argumentation and Logic aspects showed relatively lower achievement with average scores of 3.9 and 4.0 respectively, and the same percentage of 79%. This indicates that students are still having difficulty in structuring their writing well and developing logical and coherent arguments. The standard deviation values varied, with the highest being in the aspects of Reference Use (3.10) and Technical Writing Skills (3.07), indicating a fairly wide distribution of abilities among students in these two aspects. Overall, students achieved an average percentage of 82%, indicating academic writing ability in the "Capable" category. However, there is still room for improvement toward the "Very Capable" category, particularly in the aspects of writing structure and logical argumentation.

The distribution of assessment results shown in Figure 2 reveals a complex and nuanced ability profile, reflecting the inherent challenges in students' transition from technical practitioners to academic scholars.

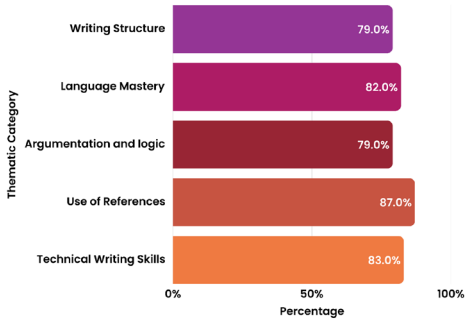

Figure 2. Percentage Distribution of Academic Writing Ability of Building Engineering Education Students.

The data collected thru questionnaires indicates that students in Building Engineering Education possess academic writing skills categorized as "Very Capable," with an overall average percentage reaching 82%. This finding signifies a significant achievement in the context of engineering education, where developing academic literacy skills is often a challenge for students with a strong vocational background. The distribution of abilities shows interesting variations: the aspect of reference usage scores the highest percentage at 87%, while abilities in writing structure and logical argumentation construction are at the 79% level [33]. This ability profile aligns with the

findings of, who analyzed grammatical complexity in academic writing by native and non-native English-speaking students, where engineering students showed unique developmental patterns in mastering various aspects of academic writing. Furthermore, text corpus-based research by on civil and environmental engineering students confirms that there are specific characteristics in the use of word clusters and linguistic markers in technical writing [34].

The dominance of ability in using references (87%) reflects an awareness among Building Engineering Education students of the importance of mature knowledge and evidence-based argumentation in academic discourse. This achievement demonstrates that students are no longer solely reliant on intuition or empirical experience, but have developed the ability to integrate scientific sources as the basis for argumentation. This phenomenon aligns with the findings of, who identified that engineering students exhibit a strong tendency to use attitude markers and explanatory codes in their academic writing, indicating sophistication in navigating academic authority [35].

Conversely, the relatively lower percentage in the aspects of writing structure and logical argumentation (78%) reveals the inherent complexity in the transition from descriptive technical reporting to academic discourse that demands a high degree of coherence and interconnectedness. This finding is consistent with analysis of interdisciplinary variation in the grammatical complexity of students' academic writing, which showed that students from engineering fields face specific challenges in developing sophisticated argumentation structures [36].

The discrepancy between high referencing skills and relatively lower argumentation structure indicates a need for more targeted and nuanced pedagogical intervention. In the context of technical education, where students are often already familiar with technical documentation and procedural writing, the transformation toward academic writing that demands critical thinking and discursive sophistication requires a systematic learning scaffold. in their analysis of article introductions in scientific disciplines, emphasize that the variation in rhetorical functions and disciplinary perspectives necessitates a learning approach tailored to the specific characteristics of each field of study [37].

The unique characteristics of Building Engineering Education students as future educators in the field of engineering add a layer of complexity, as they are required to master not only technical skills but also pedagogical discourse. This aligns with conceptualization of grammatical complexity in academic writing, where complexity does not always correlate linearly with quality, but rather depends on adherence to genre and disciplinary conventions [38].

To address the gaps in writing structure and logical argumentation, the implementation of text-based instruction shows significant potential, as validated by in their study of engineering students. The text-based instruction approach allows students to explore authentic patterns in academic discourse thru exposure to real-world examples and interactive exercises that facilitate pattern recognition and linguistic awareness [39].

Text-based methodology offers an authentic learning experience where students can identify characteristic word clusters, transition markers, and argumentative structures in academic writing. As shown in the study by, engineering students can develop sophistication in their use of linguistic markers thru guided exploration of disciplinary text collections. The use of technology allows students to analyze how often certain words appear, which words are frequently used together, and how those words function in writing, making students more aware of how to use appropriate language for quality academic writing [40].

Furthermore, integrating artificial intelligence and text corpus linguistics into writing instruction can provide personalized feedback and focused improvements for individual learning needs. This approach not only enhances the technical aspects of writing but also develops critical thinking and argumentation skills that are fundamental for academic success in the digital age and academic globalization.

The research findings on the academic writing ability of Building Engineering Education students show good ability, but there are still certain areas that can be improved. Their strength in using references indicates a solid foundation for further improvement, while weaknesses in structuring coherent writing and logical argumentation provide clear direction for learning support. The application of teaching methods using text collections, supported by new technologies and proven successful approaches, has the potential to transform writing instruction in technical education, making it more effective, engaging, and aligned with the needs of academic writing.

4. Conclusion

Based on an analysis of the academic writing abilities of students in the Building Engineering Education Study Program, this research revealed that Building Engineering Education students have achieved the "Very Capable" category with an average percentage of 80%. The aspect of reference usage showed the highest achievement (87%), reflecting good epistemological awareness in integrating scientific sources as the basis for argumentation. However, there is still room for improvement in the aspects of writing structure and logical argumentation (78%), which indicates challenges in the transition from descriptive technical writing to argumentative and reflective academic discourse. These findings highlight the need for learning innovation thru the development of an Artificial Intelligence (AI)-based system integrated with a corpus-based instruction approach to provide feedback that not only improves technical aspects but also guides the development of coherent and logical argumentation structures. The implementation of this holistic AI learning system has the potential to transform academic writing instruction in engineering education, while also supporting the achievement of SDG 4 on quality and inclusive education. Further research is recommended to develop a system prototype that can be widely applied across various engineering and vocational study programs to improve students' academic literacy nationwide.

4.1. Implication

This research makes a significant contribution to various stakeholders. For policymakers, these findings serve as a basis for designing regulations and policies for higher education that focus on improving academic literacy, such as integrating scientific writing standards into the curricula of engineering study programs and establishing minimum academic writing abilities as a graduation requirement. For educators, this research emphasizes the need to develop a curriculum that integrates corpus-based instruction and AI technology in academic writing instruction, including strengthening writing structure and logical argumentation skills thru innovative teaching methods. For higher education institutions, this study recommends collaboration with technology developers to design AI-based learning systems that can provide holistic feedback and adopt adaptive learning platforms that comprehensively support the development of students' academic writing abilities.

4.2. Limitation

The limitations of this study include: first, the survey data used is limited to students in the Building Engineering Education Study Program, so it does not fully reflect the academic writing abilities of all engineering students in Indonesia. Second, focusing on a single study program as a case study limits the generalizability of the findings to other engineering study programs or different fields of study. Third, the descriptive analysis approach used provides an initial overview but requires further testing thru experimental or longitudinal approaches to measure the impact of implementing an AI-based learning system. Fourth, this study has not yet developed the recommended AI system prototype, so the effectiveness of the proposed solution cannot be empirically verified.

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