

Artificial Intelligence Interaction in Higher Education: A Life-Course Perspective on Digital Well-Being, Learning Outcomes, Motivation, and Ethical Awareness

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ABSTRACT

Purpose – The increasing integration of artificial intelligence (AI) in higher education offers significant opportunities to enhance learning effectiveness, yet it also raises concerns related to digital well-being, learner motivation, and ethical awareness. From a life-course education perspective, early adulthood represents a critical transitional phase in which patterns of interaction with AI may shape long-term learning habits and readiness for lifelong learning. However, empirical evidence examining how AI interaction influences learning outcomes through psychological and instructional mechanisms remains limited. This study examines the effects of student interaction with AI on learning outcomes, learning motivation, and ethical awareness, with digital well-being and instructional design quality positioned as mediating variables.

Design/methods/approach – A quantitative cross-sectional survey was conducted with 145 undergraduate students at a public university in Indonesia. Data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) to examine direct and mediating relationships among the proposed constructs.

Findings – The results indicate that student interaction with AI has a significant positive effect on digital well-being, instructional design quality, learning motivation, and learning outcomes. Digital well-being and instructional design quality serve as important mediating mechanisms through which AI interaction enhances motivation and academic achievement. However, interaction with AI does not directly improve students' ethical awareness, suggesting that ethical sensitivity does not emerge automatically through AI use without explicit pedagogical intervention.

Research implications/limitations – These findings underscore the importance of designing AI-supported learning environments that promote cognitive engagement, digital well-being, and pedagogical quality while deliberately integrating ethical instruction. The study is limited by its cross-sectional design, single-institution context, and reliance on self-reported data.

Originality/value – This study contributes to the literature on artificial intelligence in education by integrating digital well-being and instructional design quality as mediating mechanisms within a life-course framework, offering insights into how AI interaction during early adulthood may influence sustainable and responsible lifelong learning.

 OPEN ACCESS

ARTICLE HISTORY

Received: 14-11-2025

Revised: 19-12-2025

Accepted: 10-01-2026

KEYWORDS

Artificial intelligence in education;
Digital well-being;
Instructional design quality;
Life-course education;
Learning motivation;

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To cite this article : Ikrananda, Amaliah, I., Rauf, A., Anam, M.Y., Suwahyu, I.. (2026). Artificial Intelligence Interaction in Higher Education: A Life-Course Perspective on Digital Well-Being, Learning Outcomes, Motivation, and Ethical Awareness. *Artificial Intelligence in Lifelong and Life-Course Education*, 1(1), 37-47.

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INTRODUCTION

Artificial intelligence (AI) has had a significant impact on the field of education through the implementation of intelligent systems that enhance personalized learning experiences. AIED technology allows the adaptation of learning materials to match students' capabilities and needs, making the learning process more flexible and efficient (Widodo et al., 2024). Previous research has shown that adaptive AI-based platforms can improve learning outcomes and reduce students' cognitive load (Zakariyah et al., 2025). Nevertheless, the use of AI in Indonesia is still underdeveloped due to low digital skills and teachers' readiness to implement the technology (Bimantara et al., n.d.). Therefore, studies on the effects of AI on learning experiences in Indonesia are very important.

Higher education in Indonesia faces various obstacles in implementing artificial intelligence-based systems, including a lack of digital infrastructure and uneven pedagogical capabilities. Many educational institutions are not yet fully prepared to integrate intelligent tools into the learning process, so the use of AIED is still not optimal. These shortcomings are further highlighted by the low level of digital literacy among students and teaching staff, which affects the effectiveness of technology use. In addition, technical support for operating adaptive systems is still uneven across different regions in Indonesia (Shafwatul Anam et al., n.d.). Therefore, it is important to investigate how student engagement with AI can influence their learning experiences.

Various studies have shown that artificial intelligence provides advantages in education through automatic feedback, better-suited material organization, and increased efficiency in the learning process. AI-based systems have been proven capable of enhancing knowledge retention and significantly reducing cognitive load when applied correctly (Naseer & Khawaja, 2025). In addition, the application of AI in personalized learning can boost students' motivation and academic achievement. Nevertheless, the effectiveness of AI use is influenced by the quality of instructional design that guides how information is delivered and pedagogical support is provided. Previous research also emphasizes the importance of ethical literacy and understanding responsible AI usage for students (Maleni et al., 2025).

Previous studies have still focused more on analyzing cognitive, affective, or ethical aspects separately in the context of AIED. Research on adaptive learning supported by AI has not fully linked student interaction with digital well-being and ethical awareness. On the other hand, AI literacy and ethics have been highlighted as important competencies in the 21st century, but their connection to motivation and learning achievement has been less studied. Furthermore, the quality of instructional design is also recognized as an important factor, but no research has comprehensively evaluated its role in strengthening the impact of student interaction with AI on learning outcomes. Therefore, efforts are needed to integrate cognitive, affective, and ethical dimensions into a holistic research framework.

This study aims to investigate the relationship between Student Interaction with AI and its impact on Learning Outcomes, motivation, and Students' Ethical Awareness. The study also considers the role of digital well-being and the Quality of Learning Design as mediating variables in the context of AI-based education. This methodology is expected to provide deeper insights into how AI technology can enhance students' learning effectiveness and digital health. Furthermore, the results of this study are expected to serve as a basis for formulating learning strategies and AI-based education policies in Indonesia. In line with this objective, the research questions used will be explained below.

Based on the background, literature review, and the analysis of research gaps above, the research questions posed in this study are as follows:

RQ 1: Does Student Interaction with AI have a positive and significant effect on digital well-being, Instructional Design Quality, Learning Outcomes, Learning Motivation, and Student Ethical Awareness?

RQ 2: Do Digital well-being and Instructional Design Quality have a positive and significant effect on Learning Outcomes, Learning Motivation, and Student Ethical Awareness?

RQ 3: Does Digital well-being mediate the relationship between Student Interaction with AI and Learning Outcomes, Learning Motivation, and Student Ethical Awareness?

RQ 4: Does Instructional Design Quality mediate the relationship between Student Interaction with AI and Learning Outcomes, Learning Motivation, and Student Ethical Awareness?

METHOD

This study uses a quantitative approach with a cross-sectional design because it allows for the analysis of relationships between variables at a specific point in time without direct intervention from the researcher. This approach is commonly used in research on the effectiveness of artificial intelligence use in higher education (Fu et al., 2025) and aims to evaluate the impact of Student Interaction with AI on Learning Outcomes, motivation, and ethical awareness, with digital well-being serving as a mediating variable. This design allows data collection to be conducted at a single point in time without direct intervention, enabling the relationships between variables to be analyzed simultaneously (Creswell, J.W., n.d.). A cross-sectional design was chosen because this study focuses on collecting data within one time period to identify the relationships between variables as they exist in an AI-based learning environment. This approach is commonly used in survey research to depict the actual conditions of phenomena without manipulating variables, and it allows researchers to efficiently analyze statistical relationships among the constructs being studied (Creswell, 2018, n.d.). Thus, this design is suitable for obtaining an empirical understanding of Student Interaction with AI, Learning Outcomes, motivation, ethical awareness, and digital well-being in the current higher education context (Sezer & Gül, 2024). By using this design, researchers can empirically examine the relationship between technology, motivation, and digital well-being in the context of students in Indonesia. It is expected that the results of this study can provide an overview of AI's contribution to improving Learning Outcomes and students' ethical awareness in the digital era.

Participants in this study consisted of 145 students who were actively studying in various majors at Makassar State University and had used AI-based learning systems, such as ChatGPT, in their academic activities. The students were selected because they were considered to represent the experience of using AI in higher education, particularly concerning its impact on Learning Outcomes, motivation, Student Ethical Awareness, and digital well-being. This approach aligns with research by, which emphasizes the importance of understanding the user context when assessing the effectiveness of AI technology in education. In addition, research by (Suwahyu et al., 2024) shows that students at Makassar State University have good AI literacy skills and actively interact with digital technology, making the participants in this study relevant as representatives of the AI user population in the educational environment high in Indonesia.

The population in this study includes all active students at Makassar State University who are involved in artificial intelligence (AI)-based learning activities across various study programs that use AI in different departments. The sampling method applied is purposive sampling, taking into account the active participation of students in digital learning and the use of AI technology in the learning process. The sample size is determined according to the rule of thumb principle, adjusted to the complexity of the research model and the number of indicators to be analyzed.

The instrument used in this study is a closed-ended questionnaire designed based on indicators from each variable being studied, namely the Relationship Between Students and AI, Academic Achievement, Motivation and Ethical Awareness, Digital Well-being, and Instructional Design Standards. This questionnaire was distributed online via Google Form to respondents who met the study criteria. All instrument items use a 5-point Likert scale, consisting of: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree. The development of the instrument was done through stages of theoretical review, adaptation of indicators from previous research, and expert judgment validation to ensure content accuracy and statement clarity before being used in data collection.

Table 1. Research Instrumen

| No | Variabel | Statement | Reference |
|----|--|-----------|---------------------------|
| 1 | Student Interaction with AI | 1-5 | (AI-Abdullatif, 2023) |
| 2 | The Impact of AI on Students' Learning Outcomes, Motivation, Ethical Awareness | 6-20 | (Mohd Rahim et al., 2022) |
| 3 | Digital Well-Being AI | 21-25 | (Gomes et al., 2023) |
| 4 | AI Instructional Design Quality | 26-30 | (Alwakid et al., 2025) |

RESULTS AND DISCUSSION

Before proceeding with a more in-depth analysis, information regarding the characteristics of the respondents who participated in this study will first be presented. A total of 145 individuals provided responses and participated in this research. To convey a clear and comprehensive depiction of the sample profile, the demographic data of the respondents is presented in Table 2 below. This information includes various key characteristics, such as gender, age range, field of study, current semester, year of enrollment, ownership of digital devices, frequency of using AI-based technology, as well as the main purposes for using AI in academic activities. Presenting these demographic characteristics aims to strengthen the contextual understanding of the research results and ensure that the analysis takes into account the background variations of the respondents.

Table 1. Respondent Demographic Data

| No | Category | Description | Percentage |
|----|------------------------------|--|------------|
| 1. | Gender | Man | 29.0% |
| | | Woman | 71.0% |
| 2. | Age | 17 | 5.6% |
| | | 18 | 40.3% |
| | | 19 | 34.0% |
| | | 20 | 18.8% |
| | | 21 | 1.4% |
| 3. | Semester | I | 49.7% |
| | | III | 43.4% |
| | | V | 6.9% |
| 4. | Cohort | 2023 | 6.9% |
| | | 2024 | 42.4% |
| | | 2025 | 50.7% |
| 5. | Major | Non STEM | 64.1% |
| | | STEM | 35.9% |
| 6. | Digital Device Ownership | No | 0.7% |
| | | Yes | 99.3% |
| 7. | Frequency of AI Usage | 1-2 Times a week | 9.0% |
| | | 3-5 Times a week | 25.7% |
| | | Rare | 5.6% |
| | | Every Day | 59.7% |
| 8. | The Main Purpose of Using AI | Studying Lecture Material | 13.1% |
| | | Helping with Assignment Writing | 9.0% |
| | | Combination (Helping with Assignment Writing, Studying Lecture Material) | 3.4% |
| | | Combination (Helping with Assignment Writing, Finding References) | 2.8% |
| | | Combination (Helping with Assignment Writing, Finding References, Studying Lecture Material) | 41.4% |
| | | Finding References | 20.0% |
| | | Combination (Finding References, Studying Lecture Material) | 10.3% |

Based on Table 2, the majority of respondents are female (71.0%) and most are in the 18–20 age group, with 18 years old being the largest group (40.3%). Academically, the majority of respondents are first-semester students (49.7%) and third-semester students (43.4%), coming from the 2025 cohort (50.7%) and 2024 cohort (42.4%). In addition, most of them come from non-STEM study programs (64.1%), indicating a variation in academic backgrounds with a greater tendency toward social-humanities fields. These findings suggest that the research sample consists of young students who are in the early stages of higher education and have the ability to adapt to technology and digital learning.

In terms of access to and utilization of technology, almost all participants have digital devices (99.3%), and the majority of them use AI daily (59.7%) or 3 to 5 times a week (25.7%). This level of usage indicates that AI has become an essential element in students' academic activities. The

purposes of using AI vary, but it is most commonly used for various learning activities, such as completing assignments, understanding lecture material, and searching for references (41.4%), followed by information searching (20.0%). Overall, these characteristics indicate that the respondents have good digital literacy skills, are very familiar with technology, and use AI as a primary tool in their learning process.

Outer Model Convergent Validity and Construct Reliability

Table 3 shows the results of the evaluation of the research instrument quality, covering six elements, namely Digital Wellbeing (DWB), Student Interaction with AI (IMdA), Student Ethical Awareness (KEM), Learning Design Quality (KDI), Motivation to Learn (MB), and Impact on Learning Outcomes (PTHB). The assessment was carried out by analyzing the outer loading values, Rho_A, Composite Reliability (CR), and Average Variance Extracted (AVE) to ensure that each indicator can truly measure the intended element in a valid and reliable manner. All indicators within each element showed outer loading values greater than 0.70, indicating a good contribution of the indicators to the respective elements. In addition, the Rho_A and Composite Reliability values for all elements are greater than the minimum threshold of 0.70, and the AVE values are above 0.50, indicating that the instrument used demonstrates good internal consistency and can explain more than 50% of the variance shown by the indicators in each element. Therefore, all elements in this study are stated to meet the required standards of convergent validity and reliability in PLS-SEM.

Table 2. Results of Evaluation of Convergent Validity and Construct Reliability

| Construct and item | Load loading | Rho_A | Composite Reliability (CR) | Average Variance Extracted (AVE) |
|------------------------------------|--------------|-------|----------------------------|----------------------------------|
| Digital Well-Being (DWB) | | | | |
| DWB1 | 0.852 | | | |
| DWB2 | 0.880 | | | |
| DWB3 | 0.826 | 0.919 | 0.938 | 0.752 |
| DWB4 | 0.875 | | | |
| DWB5 | 0.901 | | | |
| Student Interaction with AI (SIA) | | | | |
| SIA1 | 0.822 | | | |
| SIA2 | 0.827 | | | |
| SIA3 | 0.822 | 0.891 | 0.919 | 0.695 |
| SIA4 | 0.846 | | | |
| SIA5 | 0.849 | | | |
| Student Ethical Awareness (SEA) | | | | |
| SEA1 | 0.839 | | | |
| SEA2 | 0.777 | | | |
| SEA3 | 0.888 | | | |
| SEA4 | 0.880 | 0.902 | 0.924 | 0.710 |
| SEA5 | 0.826 | | | |
| Instructional Design Quality (IDQ) | | | | |
| IDQ1 | 0.864 | | | |
| IDQ2 | 0.897 | | | |
| IDQ3 | 0.794 | 0.915 | 0.933 | 0.736 |
| IDQ4 | 0.868 | | | |
| IDQ5 | 0.865 | | | |
| Learning Motivation (LM) | | | | |
| LM1 | 0.831 | | | |
| LM2 | 0.861 | | | |
| LM3 | 0.843 | 0.909 | 0.932 | 0.733 |
| LM4 | 0.867 | | | |
| LM5 | 0.879 | | | |
| Learning Outcomes (LO) | | | | |
| LO1 | 0.704 | | | |
| LO2 | 0.806 | | | |
| LO3 | 0.859 | 0.873 | 0.903 | 0.651 |

| | |
|-----|-------|
| L04 | 0.799 |
| L05 | 0.857 |

The evaluation of the measurement model presented in Table 3 shows that all constructs in this study have met the standards of convergent validity. This is indicated by the outer loading values of all indicators exceeding 0.70, which allows us to conclude that each indicator is sufficiently effective in representing the construct being measured. Furthermore, the Composite Reliability (CR) values for all constructs are greater than 0.90, indicating that the instrument has excellent internal consistency and that all indicators work harmoniously in measuring the same construct. These reliability values reinforce the accuracy of the measurement model to support further analysis. In addition, the Average Variance Extracted (AVE) values of all constructs are above 0.65, indicating that the latent variables can explain most of the variance of the indicators used. Therefore, it can be concluded that all constructs in this study are valid and reliable, so the model is ready to proceed to the evaluation of the inner model.

Discriminant Validity

Table 4 presents the results of the discriminant validity assessment using the Fornell–Larcker criteria, which aims to ensure that each construct in the model has a clearly distinct concept and does not empirically overlap with others. According to the Fornell–Larcker principle, the square root of the AVE values on the main diagonal should be higher than the correlation values between constructs in the corresponding rows and columns. The results shown in Table 4 indicate that all the values on the main diagonal are the highest in each row, for example Digital Well-Being (0.867), Student Interaction with AI (0.833), Students' Ethical Awareness (0.843), Instructional Design Quality (0.858), Learning Motivation (0.856), and Influence on Learning Outcomes (0.807), all of which are greater than the correlation values with other constructs in the same row. This illustrates that each construct has good discriminative ability and stands independently from one another within the structural model. Therefore, the discriminant validity of all constructs is met, and the model is ready to proceed to the inner model analysis stage.

Table 3. Fornell-Larcker Criteria Test Results

| | Digital Well-Being | Student Interaction with AI | Student Ethical Awareness | Instructional Design Quality | Learning Motivation | Effect on learning outcomes |
|------------------------------|--------------------|-----------------------------|---------------------------|------------------------------|---------------------|-----------------------------|
| Digital Well-Being | 0.867 | | | | | |
| Student Interaction with AI | 0.808 | 0.833 | | | | |
| Student Ethical Awareness | 0.754 | 0.666 | 0.843 | | | |
| Instructional Design Quality | 0.783 | 0.773 | 0.645 | 0.858 | | |
| Learning Motivation | 0.821 | 0.815 | 0.571 | 0.835 | 0.856 | |
| Effect on learning outcomes | 0.814 | 0.816 | 0.698 | 0.794 | 0.781 | 0.807 |

The results of the discriminant validity test based on the Fornell-Larcker criterion show that all constructs in the research model meet the discriminant validity criteria. This is evident from the square root of the AVE values for each latent variable, which are always higher than their correlations with other constructs. For example, the Digital Well-Being (Z1) construct has a square root of AVE of 0.867, which is higher than its correlations with Student Interaction with AI (0.808), Student Ethical Awareness (0.754), Instructional Design Quality (0.783), Learning Motivation (0.821), and Impact on Learning Outcomes (0.814). A similar pattern can also be observed in the Student Interaction with AI (X) construct, which records a value of 0.833, higher than all its correlations with other constructs (0.808; 0.666; 0.773; 0.815; 0.816). Meanwhile, the construct of Student Ethical Awareness (Y3) obtained a value of 0.843, Instructional Design Quality (Z2) 0.858, Learning Motivation (Y2) reached 0.856, and Influence on Learning Outcomes (Y1) was 0.807, all of which indicate AVE values that are

better than the correlations of each construct. This situation shows that each indicator within the construct has a stronger association with its variable than with other variables, so all constructs can be considered to have a clear conceptual identity without any overlapping meaning. Therefore, this research model can be stated to have good discriminant validity and is ready for further analysis at the structural relationship testing stage.

The results of the internal model analysis shown in Table 5 indicate that most hypotheses (H1–H4, H6–H8, H10–H11, and H12–H16) are significant and support the proposed conceptual model. Digital Well-being has been proven to have a positive impact on ethical awareness, learning motivation, and learning outcomes (H1–H3). Student interaction with AI also shows a strong direct influence on Digital Well-being, instructional design quality, learning motivation, and learning outcomes (H4, H6–H8). Furthermore, the mediating role of Digital Well-being and Instructional Design Quality in most paths (H12–H16) is significant, indicating that the impact of AI on motivation and learning outcomes occurs through the quality of the digital experience and the instructional design perceived by students. On the other hand, there are two hypotheses that were stated as insignificant, namely the direct impact of Student Interaction with AI on Student Ethical Awareness (H5) and the impact of Instructional Design Quality on Student Ethical Awareness (H9), as well as one insignificant mediation path (H17). Overall, these results confirm that AI has a strong influence on motivation and learning outcomes, but an increase in ethical awareness does not occur automatically without clear pedagogical interventions.

Discussion

The findings from this study indicate that the majority of the proposed hypotheses are proven to be significant, suggesting that students' interaction with AI technology, digital well-being, and the quality of instructional design greatly contribute to improving motivation and learning outcomes. However, students' ethical awareness regarding technology does not automatically emerge simply through the use of AI, thus requiring clearer pedagogical intervention. To provide a more comprehensive explanation, the results of this study were analyzed by connecting each hypothesis with previously established empirical findings.

Digital Well-Being has been shown to enhance students' ethical awareness. This aligns with the findings of research (Berger et al., 2025) which explain that digital well-being is positively related to responsible attitudes in the use of technology. By maintaining control over their digital activities, students are better able to apply ethics when interacting with AI. Digital well-being has a significant impact on learning motivation. This is supported by research, which shows that comfort in technology-based learning is associated with increased motivation and engagement. Students who do not feel pressured by digital factors are more likely to be motivated to use AI in their learning process.

Positive digital well-being can improve learning outcomes. A study by (Qureshi et al., 2024) revealed that managing technology use plays a role in enhancing students' academic performance. This suggests that skills in managing technology impact learning efficiency. Constructive interaction with AI can improve digital well-being, especially when AI helps reduce anxiety during studying. This finding aligns with research by (Abdillah et al., 2023), which revealed that support from AI can decrease academic-related pressure and stress.

This route does not have a significant impact. Students who regularly interact with AI do not automatically become more sensitive to ethics. This view aligns with research (Wiese et al., 2025) which states that without clear ethics instruction, the use of AI can lead to bias and misuse of technology in the academic world. Deep student engagement with AI can enhance their perception of the quality of instructional design. AI, functioning as a learning aid, can organize materials more systematically, provide appropriate feedback, and clarify the learning process. The findings of this study align with what (Kumar et al., 2024) stated, showing that the implementation of Generative AI is crucial in improving the quality of instructional design in online and blended learning environments, through increased effectiveness in content organization and better pedagogical support. Therefore, the better students interact with AI during learning, the more positive their assessment of the instructional design quality in technology-based courses.

The role of AI technology is very significant in boosting learning enthusiasm. This is reinforced by research (Mario et al., 2024) indicating that AI-personalized learning can increase students' interest and self-confidence. Good engagement with AI positively affects academic achievement. This aligns

with findings (Sari et al., 2024) showing that AI-supported learning significantly improves students' understanding. The effect is not significant. Without the direct inclusion of ethical material, instructional design does not build ethical awareness. This finding is in line with research (Choi et al., 2024) highlighting the importance of an AI ethics literacy curriculum.

Effective instructional design has a significant impact on student motivation. (Giasiranis & Sofos, 2020) indicate that a well-structured learning framework and immediate feedback can boost students' enthusiasm for learning. Improved learning outcomes occur when AI education is well-designed. This is supported by (Bashir, 2023), who states that instructional alignment plays a crucial role in the successful use of technology in the learning process. Significant mediation: instructional design becomes a key AI component in enhancing learning motivation. This aligns with (Ch'ng, 2023), who reveals that educational design acts as a bridge between AI benefits and motivation.

Mediation plays an important role. Artificial intelligence influences ethical norms only if the digital environment supports well-being. This finding is supported by (Veelo et al., n.d.) who revealed that proper use of technology and AI governance impacts students' ethical behavior. Learning design connects AI with learning outcomes. This statement is in line with what was stated by (Yıldızhan Bora & Şahin Kölemen, 2025), who emphasized that the use of AI in systematically pedagogical educational design can enhance.

Digital wellbeing makes the experience of using AI more engaging. According to research (Barrot et al., 2021) showing that digital anxiety can reduce motivation. Important role: Artificial intelligence enhances educational achievement without harming wellbeing. (Silva et al., 2024) show that supportive artificial intelligence improves learning outcomes. No significant influence. Consistent with without the element of ethical education, learning arrangements cannot develop moral awareness.

The findings of this study provide a significant contribution to the development of AI-based learning at the higher education level. The analysis results indicate that Student Interaction with AI can significantly improve digital well-being, learning motivation, and learning achievement. This emphasizes that the use of AI, particularly in personalized learning systems, automated feedback, and instructional design quality, needs to be designed to be more responsive, easy to understand, and relevant to students' needs. This study also enriches the literature on AIED by showing that digital well-being and instructional design quality serve as important mediators between AI use and learning outcomes as well as learning motivation. In addition, this study shows that the impact of AI on ethical awareness does not occur directly, but rather through positive digital experiences, providing a new perspective on how technology ethics can develop in a digital learning environment. However, this research has several limitations, such as relying on data from self-reported accounts and a research context that only involves a single institution, making the results difficult to generalize. Therefore, it is recommended that future research involves multiple universities, includes variables such as AI literacy or self-regulation skills, and applies mixed methods or longitudinal studies to gain a deeper understanding of the role of AI in the learning process in higher education.

CONCLUSION

This study demonstrates that student interaction with artificial intelligence plays a significant role in shaping digital well-being, learning motivation, and learning outcomes in higher education, while its influence on ethical awareness remains indirect and contingent on mediating conditions. The findings reveal that digital well-being and instructional design quality function as key mechanisms through which AI interaction enhances students' academic engagement and performance. However, the absence of a direct effect on ethical awareness highlights that responsible and ethical AI use does not emerge automatically from technological exposure alone.

From a life-course education perspective, these results suggest that AI interaction patterns developed during early adulthood—a formative stage for lifelong learning—may have enduring implications for learners' motivation, self-regulation, and learning sustainability. While AI has the potential to support adaptive and personalized learning, its educational value depends heavily on the quality of instructional design and the digital environment in which it is embedded.

Theoretically, this study extends research on artificial intelligence in education by integrating digital well-being and instructional design quality into a multidimensional explanatory model grounded in a life-course framework. Methodologically, the use of PLS-SEM provides robust empirical evidence

for examining complex mediation structures in AIED research. Practically, the findings emphasize the need for higher education institutions to design AI-supported learning environments that balance efficiency with pedagogical intentionality and explicitly incorporate ethical guidance.

Despite its contributions, this study is limited by its cross-sectional design, single-institution sample, and reliance on self-reported measures. Future research should employ longitudinal or mixed-method approaches, include multiple institutional or cultural contexts, and integrate variables such as AI literacy, self-regulated learning, and ethical reasoning to further advance understanding of artificial intelligence in lifelong and life-course education.

ACKNOWLEDGMENT

The authors would like to express their gratitude to the Informatics and Computer Engineering Education Study Program, Faculty of Engineering, Universitas Negeri Makassar, for providing institutional support and an academic environment conducive to the completion of this research. The authors also sincerely thank all students who voluntarily participated in this study and contributed their time and responses. Any opinions, findings, and conclusions expressed in this article are solely those of the authors.

AUTHOR CONTRIBUTION STATEMENT

IK conceptualized the study, designed the research framework, and led the manuscript writing. IA contributed to instrument development, data collection, and data curation. AR assisted with literature review and theoretical framing. MYA conducted data analysis and interpretation using PLS-SEM. IS provided methodological guidance, critical revisions, and overall supervision. All authors reviewed and approved the final manuscript.

AI DISCLOSURE STATEMENT

The authors used ChatGPT during the preparation of this manuscript for language refinement, structural editing, and clarity improvement. After using the tool, the authors critically reviewed, revised, and edited all content and take full responsibility for the accuracy, originality, and integrity of the publication. Artificial intelligence tools were not used in the research design, data collection, data analysis, interpretation of results, or decision-making processes.

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