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AI Literacy Development in an AI-Augmented Developmental Psychology Course: A Longitudinal Learning Analytics Study

Yu-Jing GAO
Department of Psychology, Fu Jen Catholic University,Taiwan
078148@mail.fju.edu.tw

Abstract: The rapid integration of generative artificial intelligence (AI) into higher education has highlighted the importance of developing students' AI literacy. However, limited empirical research has examined how AI literacy evolves through authentic learning processes. This study examines the longitudinal development of AI literacy in an AI-augmented developmental psychology course, employing a learning analytics approach. Repeated measurements were collected across a semester and analyzed using Generalized Estimating Equations (GEE). AI literacy was assessed across five dimensions: technical proficiency, critical evaluation, communication proficiency, creative application, and ethical awareness. Results revealed significant improvements across all five dimensions (all $p < .001$), indicating a consistent upward trajectory. The findings suggest that AI literacy develops progressively through iterative human–AI interaction, particularly through cycles of prompting, evaluation, and revision embedded in digital storytelling tasks. This study demonstrates how longitudinal learning analytics can capture the developmental trajectories of AI-related competencies in authentic educational contexts.

Keywords: AI literacy, generative AI, learning analytics, digital storytelling

1. Introduction

The rapid advancement of generative artificial intelligence (AI) has transformed human–technology interaction and positioned AI literacy as a key educational priority. Frameworks such as those from the Organisation for Economic Co-operation and Development (OECD) emphasize human-centered values, transparency, and accountability in AI use (OECD, 2024). AI literacy refers to the competencies required to understand, evaluate, and collaborate with AI systems (Long & Magerko, 2020). With the rise of generative AI tools such as ChatGPT, this concept has expanded to include skills such as strategic prompting, verification of AI outputs, and ethical awareness.

Despite increasing attention in higher education, research on how students develop AI literacy in authentic contexts remains limited, often focusing on perceptions or short-term outcomes. From a learning analytics perspective, AI literacy can be viewed as learning evidence emerging from interactions with AI systems, including prompting, revision, and evaluation processes (Siemens & Baker, 2012). To address this gap, this study investigates an AI-augmented digital storytelling approach in a developmental psychology course using a longitudinal design. By collecting repeated measurements across the semester, it examines how students' AI literacy evolves over time. This study addresses the research question: **How does students' AI literacy develop over time in an AI-augmented developmental psychology course?**

2. Theoretical and Conceptual Framework

2.1 Learning Challenges in Developmental Psychology

Developmental psychology aims to explain human development across cognitive, emotional, and social domains (Berk, 2018; Santrock, 2020), yet its theories are often complex and span multiple stages, making real-world application difficult (Ormrod et al., 2020). While active learning can enhance understanding (Freeman et al., 2014), promoting student inquiry remains challenging (Chi & Wylie, 2014). Generative AI provides new opportunities for inquiry-based learning through dialogic interaction and immediate feedback, while also generating learning traces that reflect students' engagement (Siemens & Baker, 2012).

2.2 Case-Based Learning and AI-Augmented Learning

Case-based learning supports conceptual understanding through analysis of realistic scenarios (Mayo, 2002; Hmelo-Silver, 2004), but typically relies on instructor-generated materials. Generative AI extends this approach by enabling students to dynamically create and refine case narratives.

As a cognitive partner, generative AI supports knowledge construction through iterative cycles of prompting, response, and revision (Holmes et al., 2022). These interactions both scaffold learning and produce process-level data, allowing learning analytics approaches to examine how AI literacy develops over time in authentic educational contexts (Siemens & Baker, 2012).

3. Method

3.1 Design and Participants

This study employed a longitudinal learning analytics design to examine the development of AI literacy in an AI-augmented developmental psychology course, with repeated measurements collected across the semester. Participants were 64 undergraduate students in Taiwan, primarily psychology majors. The 16-week course followed a lifespan developmental framework and integrated generative AI tools, particularly ChatGPT, into learning activities. Students used AI to generate case narratives, analyze concepts, and produce digital storytelling artifacts through iterative cycles of prompting, response interpretation, and revision.\

3.2 Instructional Design

The course adopted an AI-augmented digital storytelling design that integrated case-based learning with narrative construction. The intervention progressed through staged phases: introduction and baseline measurement (Weeks 1–3), instructor modeling of AI-supported case generation (Weeks 4–7), student collaborative case creation (Weeks 8–11), narrative integration linking theory to real-world contexts (Weeks 12–13), and final digital storytelling production (Weeks 14–15).

Throughout these phases, students engaged in iterative cycles of prompting, interpreting AI outputs, evaluating, and revising, generating process-level learning evidence that reflected the development of their AI literacy.

3.3 Measures and Analysis

Students' AI literacy was measured using the ChatGPT Literacy Scale (Lee & Park, 2024), which assesses five dimensions: technical proficiency, critical evaluation, communication proficiency, creative application, and ethical awareness. The scale was administered at multiple time points across the semester to capture longitudinal changes in AI literacy.The

instrument was administered at multiple time points throughout the semester to capture longitudinal changes in students' AI literacy.

To examine AI literacy development over time**,** Generalized Estimating Equations (GEE) were used to analyze repeated measurements of AI literacy collected across the semester. GEE accounts for within-subject correlations among repeated observations and enables estimation of population-level trends in longitudinal educational data.

4. Results

4.1 Longitudinal Development of AI Literacy

To examine changes in students' AI literacy during the AI-augmented course, Generalized Estimating Equations (GEE) were applied to repeated measurements at three time points (T2: Week 7, T3: Week 11, T4: Week 15), using an exchangeable correlation structure to account for within-participant dependence.

Results showed a significant effect of time across all five AI literacy dimensions—technical proficiency (TP), critical evaluation (CE), communication proficiency (CP), creative application (CA), and ethical awareness (EC)—with scores at later time points significantly higher than baseline (all $p < .001$). For instance, technical proficiency increased from T2 to T3 ($\beta = 3.41$, $p < .001$) and further at T4 ($\beta = 7.26$, $p < .001$), with similar patterns observed across all dimensions ($\beta \approx 3.38$–3.78 at T3; $\beta \approx 7.19$–7.74 at T4). See Table 1.

The estimated correlation parameter ($\alpha \approx .80$) indicated strong within-participant consistency alongside systematic growth over time. Overall, these findings demonstrate a clear upward trajectory of AI literacy across the semester.

4.2 Interpretation of Longitudinal Trends

The pattern of results suggests cumulative learning effects rather than immediate gains. Initial improvements between T2 and T3 indicate early development of AI-related competencies, while larger increases at T4 reflect the gradual internalization of AI usage strategies.

From a learning analytics perspective, AI literacy appears to develop through iterative interaction with AI systems. Repeated cycles of prompting, evaluating, and revising outputs—particularly within digital storytelling tasks—likely supported this progression.

Overall, the findings provide empirical evidence that integrating generative AI into disciplinary learning can foster the longitudinal development of AI literacy, highlighting the value of repeated measurement and GEE in capturing these developmental processes.

Table 1. *GEE Results for Longitudinal Development of AI Literacy*

	T3 vs T2 (β)	T4 vs T2 (β)	p-value
Technical Proficiency	3.41	7.26	<.001
Critical Evaluation	3.49	7.38	<.001
Communication Proficiency	3.75	7.74	<.001
Creative Application	3.78	7.74	<.001
Ethical Awareness	3.38	7.19	<.001

5. Discussion and Conclusion

This study This study examined the longitudinal development of students' AI literacy in an AI-augmented developmental psychology course using repeated measurements analyzed

through Generalized Estimating Equations (GEE). Results showed significant improvements across five dimensions—technical proficiency, critical evaluation, communication proficiency, creative application, and ethical awareness—indicating that AI literacy develops progressively through sustained engagement with generative AI in disciplinary learning.

The findings suggest that AI literacy should be understood as a developmental, multidimensional competency rather than an immediate skill. Students' abilities improved gradually across the semester, with larger gains emerging over time, highlighting the importance of repeated interaction with AI systems rather than brief exposure (Long & Magerko, 2020).

The study also underscores the role of AI-augmented digital storytelling tasks in supporting this development. Through iterative cycles of prompting, evaluating, and refining AI-generated content, students engaged in meaningful practice that scaffolded both technical and critical competencies.

Finally, the results demonstrate the value of longitudinal learning analytics for capturing developmental trajectories in AI literacy. Overall, integrating generative AI into disciplinary learning provides an effective approach to fostering students' competencies for interacting with AI in higher education contexts.

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