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Co-Designing AI and Multimodal Analytics Integrated Reflective Learning in Japanese High School Context

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Abstract: This research focuses on a codesign effort to integrate AI and Multimodal Learning Analytics technology and develop pedagogy for reflective learning practices. Collaborating with stakeholders from a Japanese educational con-text, researchers, students, teachers, and educational board policymakers focused on integrating Generative AI policies placed by the Ministry of Education in Japan into the activity design and the learning platform functions. The study analyzed the artifacts from the 6 participatory design sessions. These artifacts include learning activities designed by teachers and their iterations with researchers, articulation of user needs and design ideation from a co-design session conducted with students and teachers, and policy alignment of the technology and activity designed during the pilot phase. While the study demonstrates co-design steps for integrating frontier learning support tools in the Japanese context, the findings are relevant globally, and the study discusses how to balance instructional goals and technology updates in the current educational realities.

Keywords: Co-design, Generative AI, Multimodal Learning Analytics, K-12

1. Introduction

With the rise of the artificial intelligence (AI) paradigms, numerous policies and strategies for institutional adoption have been actively discussed (Ifenthaler, Majumdar et al, 2024). In Japan, the Minis-try of Education has recently also introduced policies to guide the integration of Gen-erative AI into K-12 education, prompting schools to align their technologies and pedagogies accordingly (MEXT, 2024). Many schools, already equipped with ICT infrastructure through initiatives like Google School, are well-positioned to adopt various online learning practices. However, teachers still face challenges in redesigning existing learning activities to effectively incorporate AI technologies, particularly within the time constraints of their daily schedules. Despite these challenges, there is a growing focus on digital transformation within schools, where teachers show a willingness to adopt ICT solutions that streamline tasks, gather evidence of good practice and simplify reporting and sharing. Equally important is addressing the needs of learners in this evolving educational landscape. However, to fully harness benefits of AI and multimodal learning analytics, learning activities and systems must be designed with a deep understanding of students' cognitive, emotional, and social needs. This ensures that AI-enhanced education not only supports academic achievement but also fosters critical thinking, collaboration, and digital literacy skills essential for future-ready learners.

Currently eLearning platforms have also introduced newer workflows to integrate generative AI-driven features (Arghir, 2024). While many such AI are large language model based, other forms of AI models for instance computer vision-based are still less explored. It also remains challenging to design a balanced instructional support system for reflective learning activities (Oviatt, 2018), ensuring compliance with existing policies and carefully considering how and when such AI systems can be implemented in practice. This underscores the need for strong collaboration between end-users, researchers and developers to create effective and policy-aligned solutions.

Against this backdrop, this research aims to explore the following objective: How can we design learning activities and systems that effectively leverage AI-driven features while meeting the needs of both educators and policy frameworks?

2. Literature Review

2.1 Co-designing Learning Analytics

Learning analytics is an interdisciplinary field that seeks to leverage data, system design, and educational practices to enhance teaching and learning experiences. While some efforts stem from a computational perspective, there are existing studies which deploy co-design approaches to design and develop learning analytics solutions (Sarmiento & Wise, 2022, Ogata et al. 2024). While much of the early focus has been on online settings, there has been a growing interest in integrating learning analytics into face-to-face classrooms at both higher education and school levels. These initiatives often adopt a human-centered approach, prioritizing the needs and practices of educators and learners over purely technology-driven solutions. Large-scale projects in Japan has also employed co-design approach-es (Ogata et al. 2024), fostering collaboration between educators, students, industrial partners and policy maker to ensure that learning analytics tools align with pedagogical goals and classroom realities.

2.2 Co-designing with Novice Users

Participatory design with novice users is also a challenge as their latent needs often are difficult to elicit. Lepe-Salazar et al. (2025), considered students, beginners, and enthusiasts as novices of computer science and software design who often struggle with the complexities of software design, particularly during the early stages of gathering and analyzing requirements. Mirror, is a participatory design approach that actively involves such novice stakeholders in shaping software elements. By providing structured yet flexible tools (Mirrors), the method enables participants to document their thoughts, generate ideas, and collaboratively refine design concepts. Stakeholders express their opinions, needs, and expectations through structured prompts presented as three mirrors. The First Mirror captures initial thoughts and real-world challenges, ensuring the design process starts with user realities. Participants actively contribute to generating new design components in Second Mirror. Stakeholders engage in structured self-reflection and group discussions to refine ideas in Third Mirror.

The method ensures that proposed elements align with user goals and system usability. Participants can modify, adjust, and re-evaluate their contributions in a dynamic, iterative manner. Designers act as facilitators rather than sole creators, empowering users to take an active role in shaping their digital experiences.

3. Research Context and Learning Environment

The High School. The research context involves stakeholders from a high school located in Southwest Japan. To facilitate the coordination of this project, a smaller working group was established through collaboration between the school principal and the lead teacher. The group included both native Japanese teachers and foreign English language instructors, such that it represents the diverse population that coordinates the Japanese public educational context. The coordinating teachers play a central role in aligning the project with the school's educational objectives and daily practices.

The school comprises three grade levels, each consisting of approximately nine classes with around 40 students per class. In addition to their regular academic activities, students participate in various extracurricular clubs. The teachers approached the chemistry club members to participate in the pilot activity.

Representatives from the prefectural educational board, particularly those involved in AI policy-making, also participated in the project. Their involvement ensured that the research aligned with broader educational policies and strategies concerning the integration of AI technologies in schools.

The Learning Environment. LA-ReflecT, a microlearning platform (Majumdar et al. 2023) with analytics enabled infrastructure was adopted for this study. LA-ReflecT enables teachers and learners engage in data-informed reflection on their practices. Teachers can use LA-ReflecT as an external tool integrating it with their own LMS through the LTI proto-col. They can author multimedia micro learning activities and publish it in their course. The learner can attempt the tasks in the activity and the learning design navigates them to a learning analytics dashboard immediately after attempting a task for reflecting on the learning episode. A recently enabled AI and the multimodal analytics feature supported integrated ChatGPT API and a web-based eye tracking. Figure 1 shows an overview of the teacher and learner workflow in the LA-ReflecT platform.

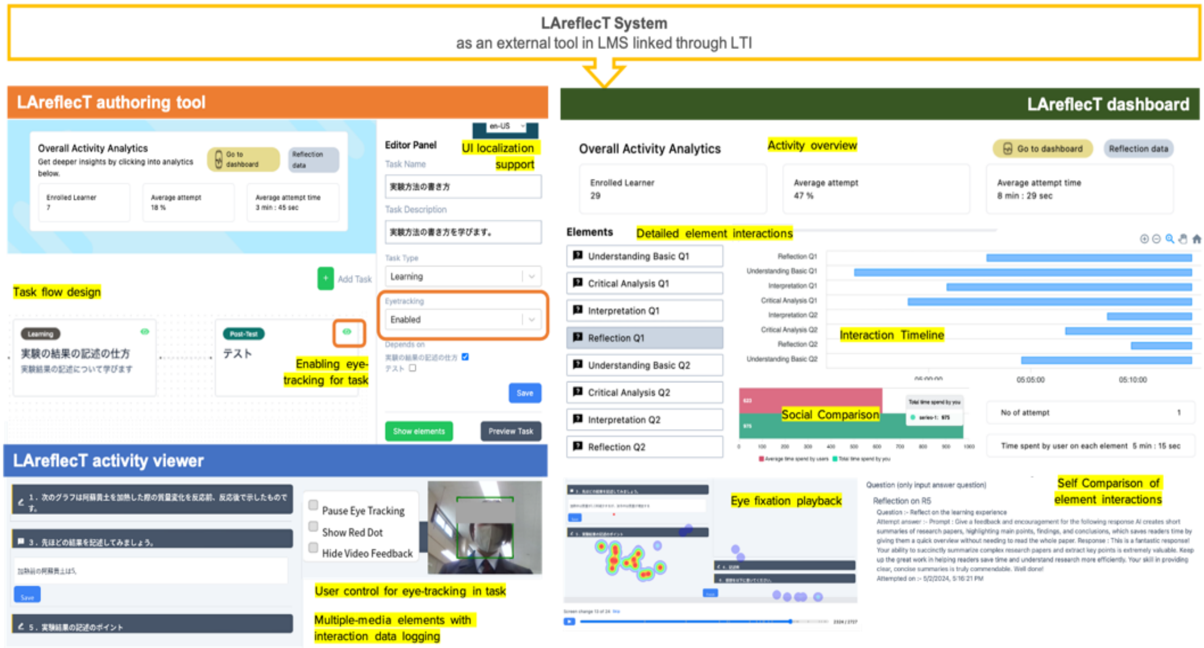

Figure 1. LA-ReflecT platform's features used in this study

4. User Study

4.1 Core Agenda of the Co-design Sessions

This research follows the participatory design iterations proposed in and for phase 1 of motivating and defining the seed design, adopted the use case regarding integrating generative AI (Majumdar, Singh & Chen, 2024) and distributed learning analytics (Majumdar, Singh, Rajendran, Narayan & Gatare, 2024) that was already studied in the higher education context. Based on that we approached the school and conduct-ed 6 co-design sessions to initiate the pilot (phase 2). The various artefacts generated during these sessions are analyzed to articulate the design process that was followed.

The six sessions involved researchers, teachers, students, and the educational board representatives. The first session (22 Sep, 2024 – in person with researchers, school management) introduced the project's objectives and the learning tools, while also reviewing the school's IT infrastructure and the consent procedures for student participation. In the second session (12 Dec, 2024 – online with researchers and school management), researchers discussed the ethics board's approval and the implementation of consent processes, including offline parent consent forms and an opt-out option for data logging. A

Moodle site was shared, featuring the learning tool and a demonstration video. An initial activity integrating ChatGPT into LA-ReflecT was introduced, and teachers were encouraged to create their own activities. In the third session (8 Jan, 2025 – online), three teachers presented activities on information security, chemical experimental methods, and friction. The research team reviewed these and suggested adding feedback prompts through ChatGPT. Eye-tracking and dash-board features were also demonstrated. Five chemistry club students were recruited for a pilot study. The fourth session (23 Jan, 2025 – hybrid) had students complete one activity in-session, with two others done independently. In the fifth session (5 Feb, 2025 – online), the research team reviewed the pilot with school staff and educational board members, discussing policy alignment and feedback strategies. The final session (14 Feb, 2025 – in person) was a design workshop using the Mirrors tool (Lepe-Salazar et al., 2025) to explore reflective learning and AI integration.

4.2 Insights from the Co-design Sessions

Elicit needs of AI and multimodal analytics integration with value proposition.

Researchers and teachers interacted to iterate the three original activities and discussed the inclusion of AI and multimodal analytics support. We present the core value proposition that emerged in reference to two of those activity redesign.

For the activity on the topic of friction, there was a learning and a posttest task. The learning task had multiple resources such as interactive physics simulations available on PhET (phet.colorado.edu), content reflection prompts that was added by the teacher as elements in LA-ReflecT. The teacher included a particular roller skating track design as a problem to then discuss various concept of potential and kinetic energy. In the post test, a similar problem with a new track design was given. Here the teachers included AI-based hints after the first round of discussion with the researchers. They wanted to investigate the differences when the hint is presented as a feedback versus as a chatbot (as presented in Figure 2).

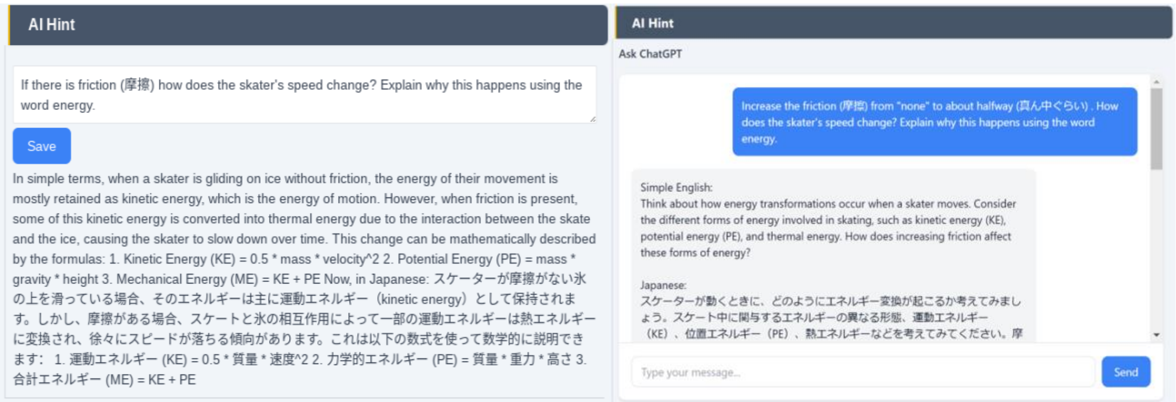

Figure 2. Implementation of AI hint as a hint and chatbot

Value proposition: To enhance existing instructional design, incorporating teachers' interests in reflecting on their practices creates opportunities for integrating innovative tools and services. In this case, the use of generative AI as a hint-providing tool allowed the teacher to explore various interaction modalities and examine how different prompting strategies influence AI-generated responses. This approach fosters deeper engagement and supports continuous instructional improvement.

Another activity on chemical experiment methods included a learning task and a posttest, completed by students during the first demonstration with eye-tracking enabled. The tasks involved graph reading and interpretation. The teacher aimed to highlight differences in students' attention patterns (Figure 3) and their focus shifts be-tween the learning and assessment tasks. As a formative assessment, students were encouraged to review their performance on the dashboard for reflection.

Value proposition: Integrating multimodal analytics, such as web-based eye tracking, offers valuable opportunities for social comparison of learning behaviors over time and across groups, benefiting both teachers and students. This approach not only supports deeper insights into engagement patterns but also sparks curiosity about the technology’s accuracy and the validity of its computed indicators, fostering a more reflective and data-informed learning environment.

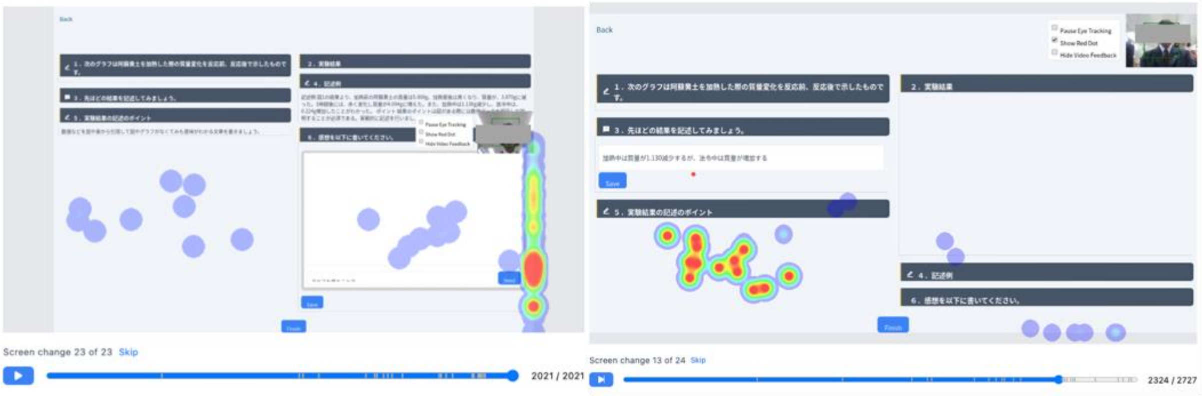

Figure 1. Eye tracking for different students attempting the same task.

Elicited user needs and ideas from mirror artefacts. 3 students and 2 teachers expressed their needs and ideas with the mirror task. In mirror one (related to issue), one theme emerged as the difficulty in reflection on ones mistakes, study methods and data needs (core issues, S1: “Reflect on the mistakes I made and get the reasons for them”, S3: “I can't remember the study methods I used in the past.”, T2: “I want to know how other people study, the difference between good and bad students”). Another core issue was related to motivation to act and monitor (S2: “I don’t like to study, but I like when it is gamified”, T1: “I can't maintain my motivation for studying English or taking qualification exams”).

Peer comments in mirror two were shared for each issues and approaches. While AI-driven analysis was valued students also desired insights from specialized teachers and peer opinions, fostering a sense of camaraderie, especially when common mis-takes are identified. Participants noted that different individuals are motivated by varying factors, suggesting the integration of gamification elements tailored to user preferences. Further an AI for finding and categorizing different study methods was thought useful, but users should have the control whether their method should be shared with others. In Mirror three some specific ideas were shared incorporating the discussions and feedback. For instance, S3 mentioned about a platform where you can share the study methods you have used "Like" and save the study method → Try it out, and use AI analysis to see if it's effective → Brush up on one's study method. See Figure 4 shares artefacts created in Mirror 3 form by other participants (S1, S2, T1). They have shared various functions for gamification of the daily learning process which might motivate learners to continue in a self-directed way.

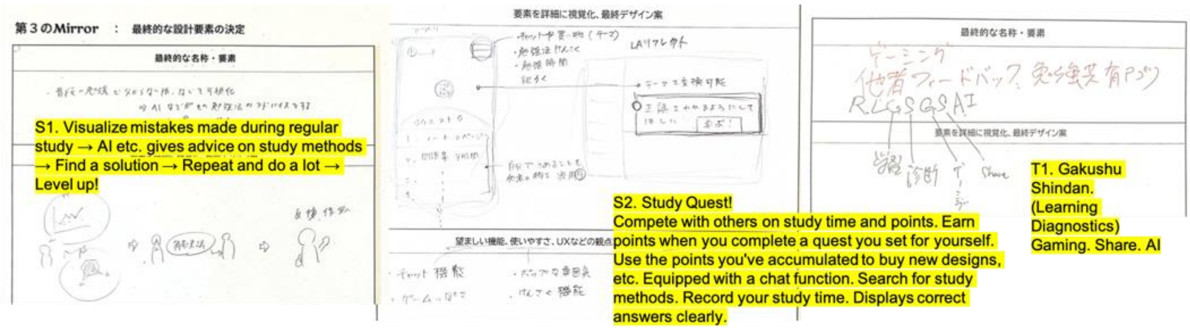

Figure 4. Design ideas that evolved amongst students and teachers in Mirror 3

5. Discussion and Future Work

This study elaborates a systematic co-design effort while piloting an eLearning tool that incorporates AI and multimodal learning analytics functions. The Japanese educational policy, with regards to the use of Generative AI, also recommends protecting learners specially at K12 level by ensuring a teacher guided use. Such a support is possible in tools like LA-ReflecT that enables authoring of activities and tracking of use based on users role. It further empowers learners to actively use data for self-improvement and goal attainment.

The described short yet frequent co-design session is what was effective in gathering the needs and refining the idea. After this initial phase, a teacher and researcher group co-developed and implemented a learning activity in one class with 40 students as pilot to group learners based on learning behaviors captured with multimodal data (Majumdar et al. 2025). We repeated the mirrors activities with those students and currently analysing to elicit further needs and ideas. A new round of revision of the functions, workflow and activity design will start after that. While the study is in the Japanese context, cross cultural studies are necessary as different countries are coming up with different policies related to AI in education (Bhutoria, 2022).

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