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Teaching Analytics with xAPI: Learning Activity Visualization with Cross-platform Data

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Abstract: This study explored the possibility of teaching analytics utilizing daily learning log data recorded in xAPI format for class activity visualization. A junior high school reading activity designed to utilize several ICT tools distributed among multiple platforms was visualized. The visualized class activity was shown to a learning designer of the reading activity unit and then asked what she realized when revising the class activity design. As a result, we found that the integrated learning logs processed from the xAPI could visualize the differences in the actual activities compared with the lesson plan and how active the learners were. In addition, when the learning designer saw this visualization, she expressed her desire to change the activity design to reduce the transition of activities during class. Based on these results, we concluded that the daily learning log data recorded in the xAPI could visualize the time and content of the activities performed by the learners. The results show the possibility of capturing and visualizing the progress of a class by cross-platform analysis using xAPI instead of using multiple special sensors.

Keywords: Teaching Analytics, xAPI, Learning Design, Learning Analytics

1. Introduction

Analyzing and visualizing class activities is called teaching analytics and is essential for research and the professional development of teachers (Hoyos & Velásquez, 2020). Several studies have been conducted to capture learning traces from face-to-face learning contexts. The primary approach to this is Multimodal Learning/Teaching Analytics with various types of data, such as audio, video, text, speech, gestures, and eye-gaze (Ochoa et al., 2017; Prieto et al., 2018; Ndukwe & Daniel, 2020; Martinez-Maldonado et al., 2020). However, learning tools have been increasingly used in the daily teaching context which often enable logging of user interactions in the system. Additionally, some learning tools support xAPI, enabling learning log integration and cross-platform analysis (CPA) (Mangaroska et al., 2019). CPA with xAPI is expected to work as an alternative solution for multimodal sensors.

Given this background, this study explored the possibility of utilizing daily learning log data recorded in xAPI for class activity visualization in teaching analytics. We visualized the reading activity, which was designed to utilize several ICT tools distributed across multiple platforms, and examined the insights that the visualization could provide to reflect on and revise the class activity design. The research questions for this study are as follows:

- **RQ:** To what extent can the daily learning log in xAPI format capture class activities for teaching analytics?

2. Methods

2.1 Methods Overview

This study targeted learning activities that had tasks across multiple platforms. Learning activity visualization was performed using the learning log data collected naturally during the learning activity.

Figure 1 presents an overview of this study. LEAF (Learning and Evidence Analytics Framework) is the Integrated Learning Environment in which the learning activities in this study were conducted. The LEAF system consists of a learning management system (LMS; Moodle), e-Book (BookRoll), learning record store (LRS), and learning analytics tools (log palettes) (Ogata, et al., 2018). All learning logs from these platforms are stored in one LRS in the xAPI format, and logs can be recorded using a unified UUID on the LRS.

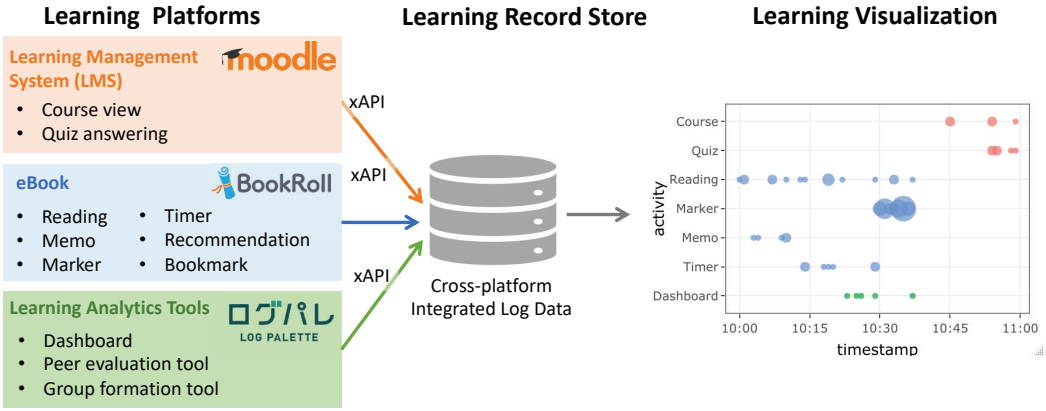


Figure 1. Visualization Method for Class Activities with Cross-platform Log Data.

Based on cross-platform integrated log data, we visualized the learning activities of a class. The lesson plan and visualization were shown to a learning designer and a learning analytics researcher who designed the reading activity unit and was asked what they realized for revising the learning design and lesson plan.

2.2 Context

This study focuses on a Japanese junior high school English class with the following class design: The target class used a technique called data-enhanced active reading (Toyokawa et al., 2023), which is a reading class that uses e-Books and learning analytics tool to display logs. Figure 2 shows the lesson plan and the learning platforms used on that day.

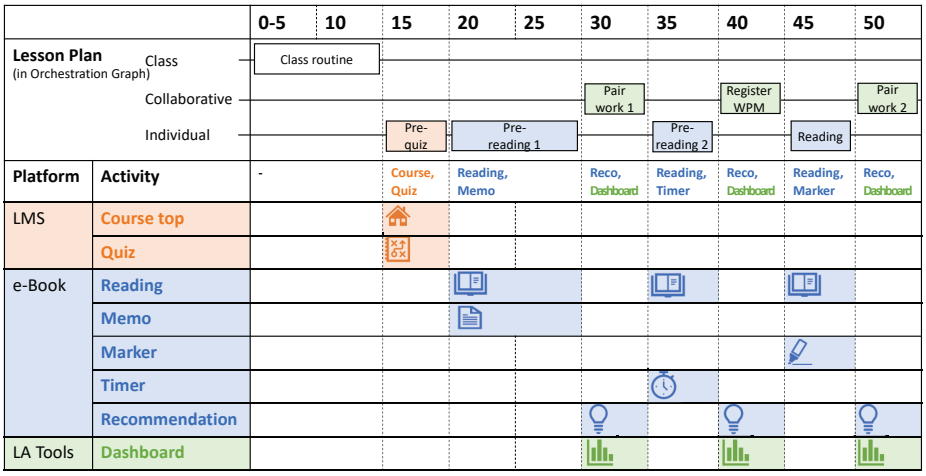


Figure 2. Detailed Lesson Plans and Used Learning Tools.

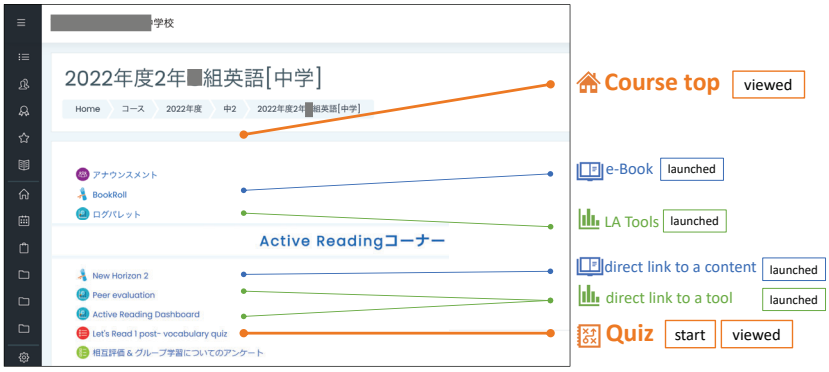
The lesson plan started with routine activities (dictation, 1 min. reading, etc), followed by a pre-quiz. This was followed by pre-reading, which consisted of reading the text and writing guesses and questions in the e-Book memo. Then, as a Pair Work 1 activity, activities were planned to access the dashboard and share guesses and questions with peers by checking the dashboard. In Pre-reading 2, students were expected to read the passage silently and record their reading time with the e-Book timer. They then accessed the active reading dashboard and registered with their words-per-minute (WPM). Next, they

reread the text and highlighted unknown words and essential points with the e-Book marker. Finally, as in Pair Work 2, the dashboard was accessed, and unknown words and essential points were discussed with peers by rechecking the dashboard.

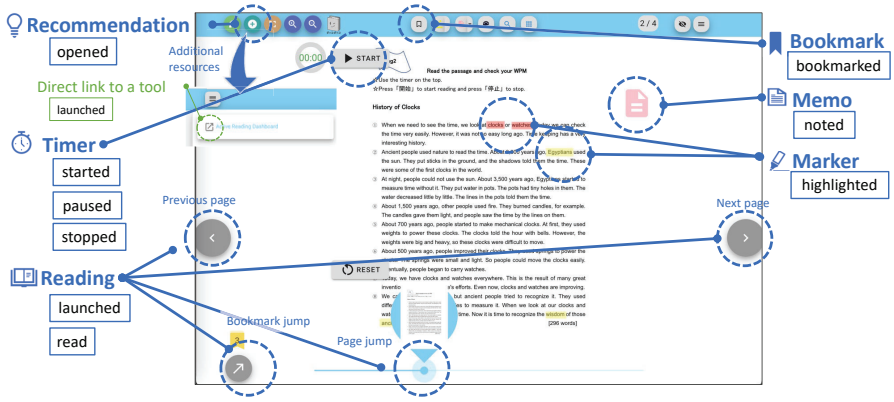
As described above, the lecture utilized a variety of learning platforms and was designed to combine individual and collaborative activities alternately. Further, this class was not designed for the instructor to give a lecture in front of the students, but rather for the students to proceed with the activities themselves according to their teacher's instructions.

2.3 Interface, verbs, and activities

Figure 3 shows the interfaces of the three platforms used in the learning activities. When users click each button or link, the learning log is stored in the LRS along with the verbs shown on the side. Visualization was performed based on the logs stored in the LRS. At this time, to make the activity granularity suitable for the visualization of this lesson plan, some verbs were adjusted as grouped or divided into several activities as shown in Figure 3.



(a) Learning Management System



(b) e-Book

(c) Learning Analytics Tools

Figure 3. The Interfaces of Learning Platforms and Verbs.

3. Results and Discussion

Figure 4 shows the activities during the 50-min class, aggregated every minute. The size of each dot represents the number of activities. The vertical axis represents the learning activities shown in Table 1, and the horizontal axis represents time. Each cell in the plots represents a student's activities, and the bottom cell shows the teacher's activities. Due to space limitations, only 15 learners out of 38 students were randomly selected for Figure 4.

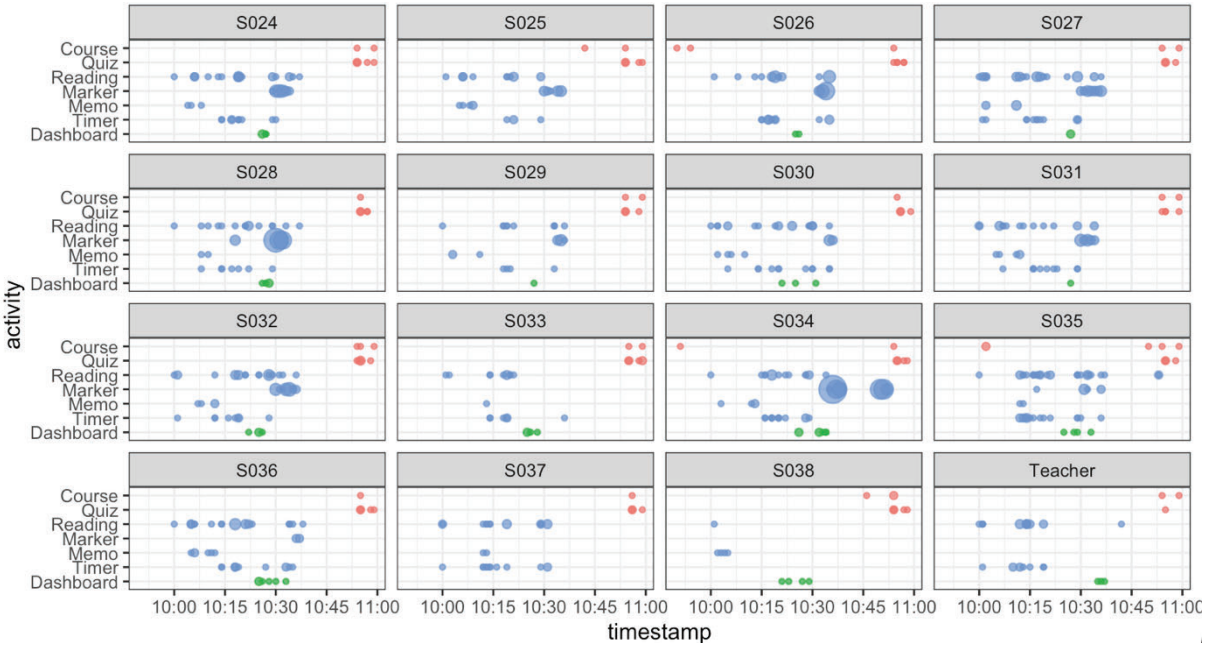


Figure 4. Learning Activity Visualization from Integrated xAPI Log Data.

3.1 To what extent can xAPI learning log data capture class activities?

Based on these visualizations in Figure 4, we first analyzed to what extent xAPI learning log data can capture and visualize class activities.

(1) How the class proceeded
The plots in the figure indicate who used the tool, when, and how many times. Thus, this visualization can provide an overview of the class's progress. The results showed the order in which the tools were used, the differences in tool use timing, and the number of times it was used depending on the person. For example, with the integrated xAPI logs capturing and portraying how the class actually proceeded, almost all students in this class first used the e-Book (blue dots), followed by the dashboard (green dots), and the LMS (red dots) at the end of the class. In addition, this visualization captures variations in how many times (size of dots) and how much time (width of a series of dots) each student performed actions.

(2) Deviation from the lesson plan during the actual activity
Comparing the plan and the whole class activities, the LMS activities represented by the red dots were planned at the beginning of the class but were actually completed at the end of the lesson. This can be interpreted as the teacher changing the lesson plan. In addition, it was planned that the students would use the recommendation in the e-Book to guide their access to the dashboard, but no one used it. This could be because the instructions for the recommendation function were not clear, as they did not realize the function. In this way, this visualization can also assist in assessing how well the lesson progressed as planned.

(3) Whether the students could follow the activity and tool transitions
Regarding the activity with the dashboard represented by the green dots, some students accessed it three times as planned, but others accessed it only once, and a few did not

access it even once. One of the reasons for this could be that the dashboard was not a function in the e-Book but was on learning analytics tools, a different platform launched from LMS. Thus, students found it challenging to access it. In addition, the activities using the dashboard were collaborative; therefore, there were hurdles. In other words, this visualization can explain the difficulty of transitions among tools and activities.

(4) Teacher's behavior and deviation from the lesson plan and students' activity
Finally, even though teachers accessed all the LMS, e-Books, and learning analytics tools, the timing did not necessarily match the lesson plan and that of the students. In addition, the teacher accessed the quiz for LMS (red dots) and the dashboard for learning analytics tools (green dots), and only the reading and timer for the e-Book (blue dots). Thus, we found that even though it is teaching analytics, it is necessary to pay attention to the logs of the teacher and the learner, especially in the case of a class designed in such a way that students develop activities according to the teacher's instructions rather than being led by the teacher.

3.2 What kind of insight can the visualization give for the improvement of the learning design?

Second, we showed these visualizations to a researcher who designed this reading activity and asked her what she noticed. We also asked where and how she could improve the lesson plan and learning design.

3.2.1. What the learning designer noticed from the visualization

(1) Unexpected number of page transitions and operations
The learning designer pointed out that the number of reading and timer logs was higher than expected. The reading material consisted of only four pages, each of which corresponded to the activities in the lesson plan, as shown in Figure 2. When it was designed, it was supposed to be read only once per page from the front. However, reading logs appeared in a band shape, implying that page transitions are performed multiple times. The designer mentioned two possible interpretations: one is that students worked diligently, and the other is that the material was not easy to follow and required reviews of the previous pages.

(2) Much time spent on individual activity and less collaborative activities
The designer also focused on the difference between e-Book and dashboard operation logs. Considering that the e-Book reflects individual activities and the dashboard reflects collaborative activities in this design, she reflected as follows: "I am happy they worked hard on e-Book activities, but individual activities may have been more difficult than I expected. I would like to make collaborative activities more active, and modify the plan not to focus on individual activities overly."

3.2.2. What suggestions the designer had for improving the lesson plan and learning design

(1) Activity design improvement: transition between activities and platforms
She noted that the designed lecture had activity switching and movement between platforms, especially with some learners not performing the activities as planned; thus, she would like to reduce back and forth between activities and platforms to remedy the problem. As a concrete measure, she would simplify the activities slightly more while being careful not to lose the purpose of each activity.

(2) System design improvement: gather the functions for one activity in one platform
She also mentioned the system improvement. As mentioned in 3.1 (3), the dashboard was not a function in the e-Book, and some students accessed it only once or did not access it even once. Based on this, she said that if the dashboard could be viewed from within the e-Book, the number of students who could view the dashboard would increase, and collaborative activities would be more active.

4. Conclusion and Future Works

In this study, we set the research question as “To what extent can the daily learning log in xAPI format capture class activities for teaching analytics?” To answer the question, we visualized the reading activity, which was designed to utilize several ICT tools across multiple platforms, and examined the insights that the visualization can provide for reflecting on and revising the activity design.

The results showed that the integrated xAPI logs could visualize whether there were any differences in the actual activities compared with the lesson plan and how active the learners were. In addition, the learning designer mentioned her desire to change the activity design to reduce the transition of activities during class. Based on these results, we concluded that the daily learning log data recorded in the xAPI could visualize the learning activities for teaching analytics.

This study had some limitations. First, our method captured and visualized an entire class activity and compared it with a learning design. However, it should be noted that the target class was designed with activities that used tools frequently. For example, if a class uses only e-Books with few tools, or a class that does not use tools at all, the method captures only a portion of the activity. Second, in this study, we presented the visualization results to the learning designer to see how they would interpret them. However, we would like to show this to teachers and observe how they interpret the visualization. In addition, teachers do not necessarily have sufficient data literacy to interpret learning analytics results (Ndukwe & Daniel, 2020). To solve this problem, feedback should have guiding perspectives instead of simply mirroring the activity (Soller et al., 2005).

Although this research is still in an exploratory phase, it shows the possibility of capturing and visualizing the progress of a class using xAPI instead of multiple sensors.

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References

Hoyos, A. A. C., & Velásquez, J. D. (2020). Teaching Analytics: current challenges and future development. *IEEE Revista Iberoamericana de Tecnologias del Aprendizaje*, *15*(1), 1-9.

Mangaroska, K., Vesin, B., & Giannakos, M. (2019, March). Cross-platform analytics: A step towards personalization and adaptation in education. *In Proceedings of the 9th international conference on Learning Analytics & knowledge* (pp. 71-75).

Martinez-Maldonado, R., Echeverria, V., Fernandez Nieto, G., & Buckingham Shum, S. (2020, April). From data to insights: A layered storytelling approach for multimodal learning analytics. In *Proceedings of the 2020 chi conference on human factors in computing systems* (pp. 1-15).

Ndukwe, I. G., & Daniel, B. K. (2020). Teaching Analytics, value and tools for teacher data literacy: A systematic and tripartite approach. *International Journal of Educational Technology in Higher Education*, *17*(1), 1-31.

Ochoa, X., Lang, A. C., & Siemens, G. (2017). Multimodal learning analytics. *The handbook of learning analytics*, *1*, 129-141.

Ogata, H., Majumdar, R., Akçapınar, G., Hasnine, M.N., & Flanagan, B. (2018). Beyond Learning Analytics: Framework for Technology-Enhanced Evidence-Based Education and Learning, in Proceedings of the 26th International Conference on Computers in Education, 486-489.

Prieto, L. P., Sharma, K., Kidzinski, Ł., Rodríguez-Triana, M. J., & Dillenbourg, P. (2018). Multimodal Teaching Analytics: Automated extraction of orchestration graphs from wearable sensor data. *Journal of computer assisted learning*, *34*(2), 193-203.

Soller, A., Martínez, A., Jermann, P., & Muehlenbrock, M. (2005). From mirroring to guiding: A review of state of the art technology for supporting collaborative learning. *International Journal of Artificial Intelligence in Education*, *15*(4), 261-290.

Toyokawa, Y., Majumdar, R., Kondo, T., Horikoshi, I., & Ogata, H. (2023). Active reading Dashboard in a Learning Analytics enhanced language-learning environment: effects on learning behavior and performance. *Journal of Computers in Education*, 1-28.