Visualization of Instructional Patterns from Daily Teaching Log Data

Kohei NAKAMURA[a], Izumi HORIKOSHI[b], Rwitajit MAJUMDAR[b] ,Hiroaki OGATA[b]
a Graduate School of Informatics, Kyoto University, Japan
b Academic Center for Computing and Media Studies, Kyoto University, Japan
***nakamura.kohei.42r@st.kyoto-u.ac.jp**

Abstract: Reflections are said to improve teachers' professional skills. Questionnaires and video-recording methods require advanced preparation, which is often burdensome for teachers and students. In recent years, researchers have turned to analyzing the log data of ICT systems. This method is less demanding and helps clarify the educational process. Also, with multiple classroom systems, we propose a visualization method to track teachers' instructional patterns. Our goal is to clarify differences in teaching using actual teacher-log data. It was found that the method of using the system differed depending on each teacher. This method allows us to improve education quality by facilitating teachers' reflections and fostering discussions with colleagues.

Keywords: Instructional pattern, xAPI, teaching analytics

1. Introduction

Reflection on teaching practice plays an important role in teacher professional development (TPD)(Postholm,2008). It is not only effective to reflect on one's educational practices but also on those of other teachers' educational practices. (Kleinknecht & Schneider, 2013, Koukis, & Jimoyiannis, 2019). TPD encompasses various approaches, but its ultimate objective is to improve practice and facilitate student development (Avalos,2011). Therefore, it is necessary to gather data from daily classroom practice.

In general class practice, data collection often collected time slots and methods such as questionnaires, audio, and videos (Cherrington & Loveridge, 2014). However, this process can be burdensome for teachers and costly. (Martínez et al., 2022). Therefore, there is growing interest in utilizing teachers' log data collected from daily classroom practice (Hoyos &Velásquez, 2020). For instance, Regueras et al. (2022) used dashboards to visualize teachers' utilization of learning management systems (LMS) based on log data to support reflection.

It is important to recognize that teachers often use multiple ICT tools for effective instruction (Mangaroska et al., 2021). Consequently, relying on data from a central platform, such as an LMS, may not accurately the dynamics of a real classroom. Examining how teachers employ multiple systems and analyzing the teaching process is crucial to gain a comprehensive understanding of teaching practices. (Leeuwen, et al., 2019) For instance, Nakamura, Horikoshi, and Ogata (2022) utilized xAPI to analyze teaching practice across multiple ICT tools and visualize the process.

The teaching practice and process involve instructional patterns, which are strategic methods teachers used by teachers to guide student learning. Lin et al. (2020) conducted a study on instructional patterns for teaching and learning argumentative writing, where they observed how teachers combine various methods to teach different argumentative components. We aimed to identify the instructional patterns of Japanese junior high school teachers.

In this study, we aim to clarify the difference in teaching by utilizing multiple systems. We will improve Nakamura et al.'s method (2022) and visualize the instructional patterns of teachers. The research questions guiding our study are as follows:
RQ1: What kind of ICT tools do teachers use to teach daily?

RQ2: Do instructional patterns differ depending on tool use experience?
RQ3: Is there a difference in instructional patterns using ICT tools among the same subjects?

2. Method

2.1 Learning Evidence Analytics Framework (LEAF)

The LEAF system (Figure 1) was used to collect Log data for this study. The system comprises three subsystems: the learning management system (LMS) "Moodle," the e-book reader "Bookroll," and the learning analysis tool "Logpalette" (Ogata et al., 2018). These subsystems are independent systems interconnected through Learning Tools Interoperability (LTI). The log data from each system were stored as xAPI in the Learning Record Store (LRS). Teachers are in a digital educational environment where LEAF can be used daily, but its use is at the teacher's discretion.

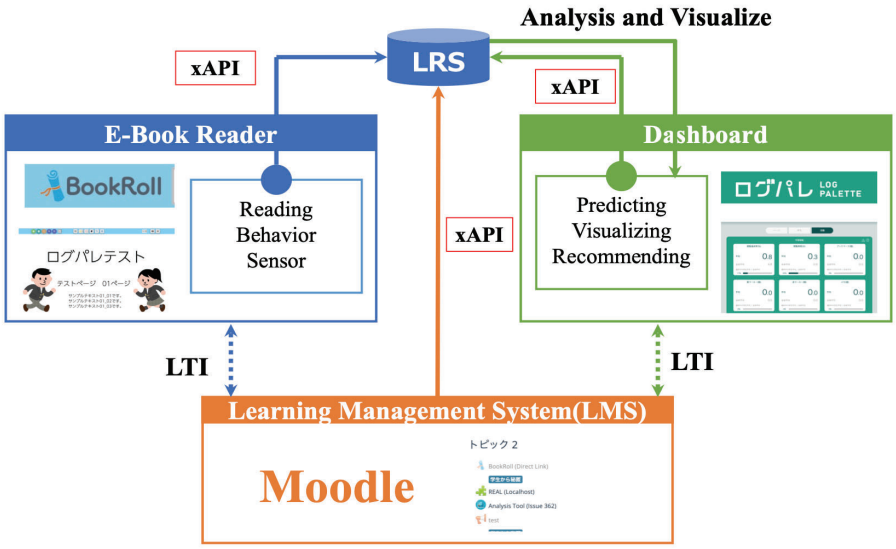


Figure 1. Overview of the LEAF system

2.2 Participants and Contexts

This study used observational data from the LRS and involved 22 junior high school teachers. The data were collected from the LEAF system between April 1st and September 30th, 2022. Upon analyzing data from 22 teachers, it was observed that most teachers who used multiple systems daily were math teachers.

2.3 Data parsing and visualization technique

During the study period of 6 months in 2022, a total of 22 teachers generated 53,393 statements. To focus on the use of ICT tools, we filtered logs where these tools were used at least twice. This resulted in the extraction of 3,095 classes based on the timetable. Specifically, when we extracted the classes of four mathematics teachers, we found that there were 552 classes during the target period. From these classes, we further extracted 75 classes to specifically analyze the instructional patterns within the same subjects. We analyzed the xAPI statements and extracted information on (1) the system used, (2) the specific tool used, and (3) the type of operation performed (Figure 2). Through this analysis, we identified a total of 29 types of processed data. Additionally, based on the functions of each system (LMS, E-

book reader, and Learning Analysis tools), as shown in Figure 3, we prepared and analyzed 12 types of teachers' behaviors.

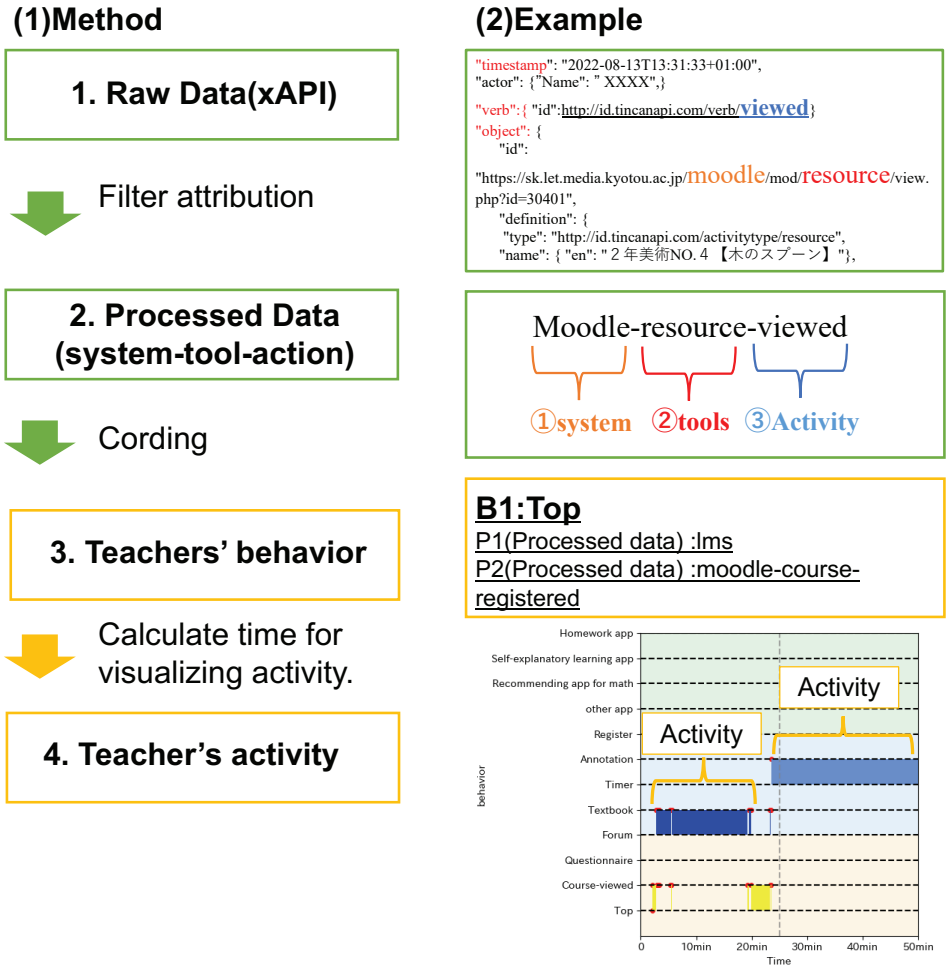


Figure 2. The procedure of data parsing and the number of data points collected in this study

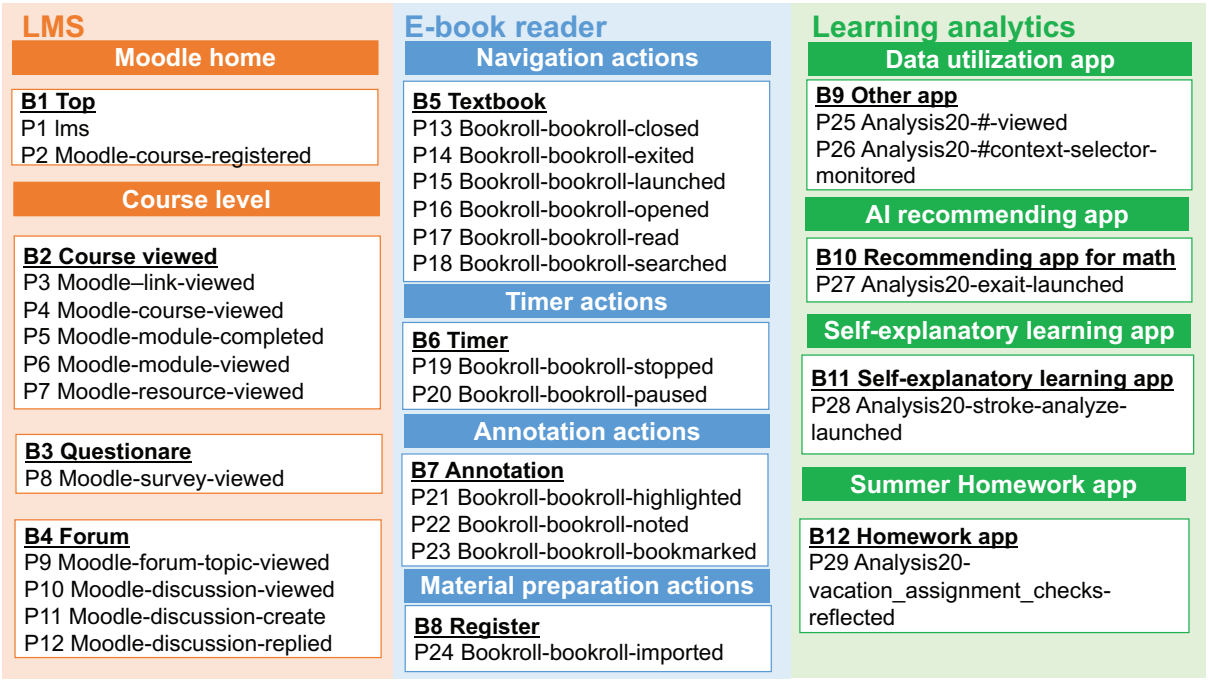


Figure 3. Types of teacher behavior in the LEAF system and their corresponding processed data

All the classified processed data were point-process data. It is important to explain which tools were used, when, and for how long to gain a better understanding of the instructional process. Figure 4 illustrates this by representing click events as red dots and adding the time between events to depict tool usage time. Additionally, to identify the system from which the data originated, LMS-related data were assigned the color orange, e-book-related data were presented in blue, and analytics tool-related data were shown in green. Each event was assigned a unique color. The y-axis represents the processed and classified data, as shown in Figure 4, while the x-axis represents time. The time is divided into intervals of 1 min, with each interval corresponding to half of the timing, from the start to the end of the lesson. Finally, we visualized the teaching process, as shown in Figure 5.

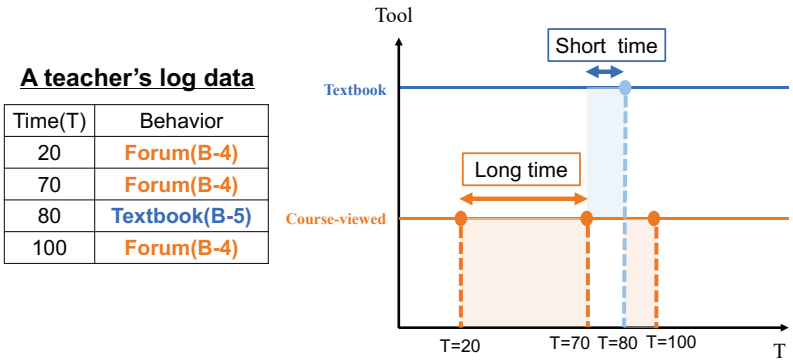


Figure 4. How to visualize teachers' activity from point process data

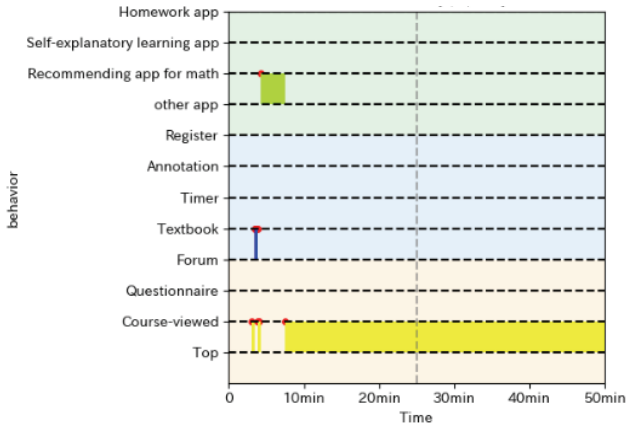


Figure 5. Proposed visualization method

2.4 Data Analysis Method

We performed three analyses to answer the three RQs we set.

(1) Analysis 1: Exploring the Daily Use of ICT Tools in Teaching (To answer RQ1)

During analysis 1, we investigated the systems utilized by the four mathematics teachers used in their classroom practice and compared them to the usage pattern of all 22 teachers. As part of this analysis, we aggregated and analyzed the combination of each system and the number of classes held.

(2) Analysis 2: Analyzing Differences in Instructional Patterns Based on LEAF Experiences (To answer RQ2)

We overlaid the diagrams generated using the proposed method (Figure 6) with image transparency set to 0.5. Therefore, the overlapped portion appeared in a dark color. By referring to the usage history and usage of ICT tools, we clarify the differences in teachers' instructions across multiple systems.

(3) Analysis 3: The differences in instructional patterns using ICT tools (To answer RQ3)

To investigate differences in instructional patterns, we examined 75 classes taught by four mathematics teachers within the designated period. The analysis involved using the proposed visualization method to identify and analyze variations in instructional approaches.

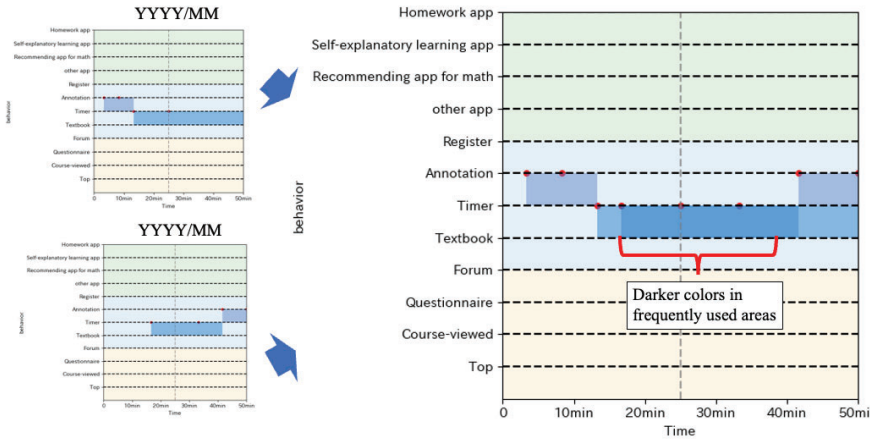


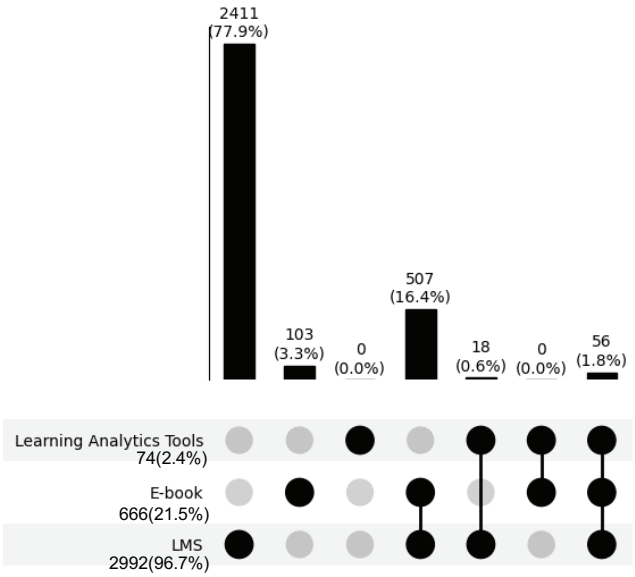
Figure 6. The overlay method for visualizing instructional patterns

3. Results and interpretation

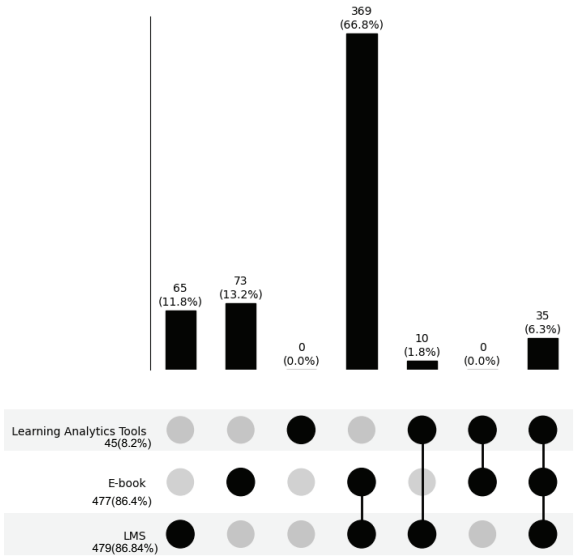
3.1 RQ1: What kind of ICT tools do teachers use to teach daily? (Analysis 1)

In addressing our first research question, we sorted to gain a deeper understanding of the specifics of ICT tool usage. Then we uncovered the preferences and practices of teachers in their daily classes. Figure 7 shows the systems employed in teachers' classes from April 1st to September 30th, 2022. In the analysis of class situations for the 22 teachers (Figure 7(a)), we found that LMS was the most frequently used ICT tool independently (N = 2411, 77.9%). The second most common combination was LMS and E-book reader (N=507, 16.4%).

Conversely, Figure 7(b) reveals the combination of LMS and E-book reader was the most popular system choice among all four math teachers (N=369, 66.8%). The next frequently used classes were E-book reader (N=73, 13.2%) and classes solely utilizing an LMS (N=65, 11.8%). This indicates that mathematics teachers used the system differently than teachers in charge of other subjects.



(a) Usage by all 22 teachers in 3,095 classes



(b) Usage by four mathematics teachers in 552 classes

Figure 7. The usage of LEAF subsystems in daily class during the period

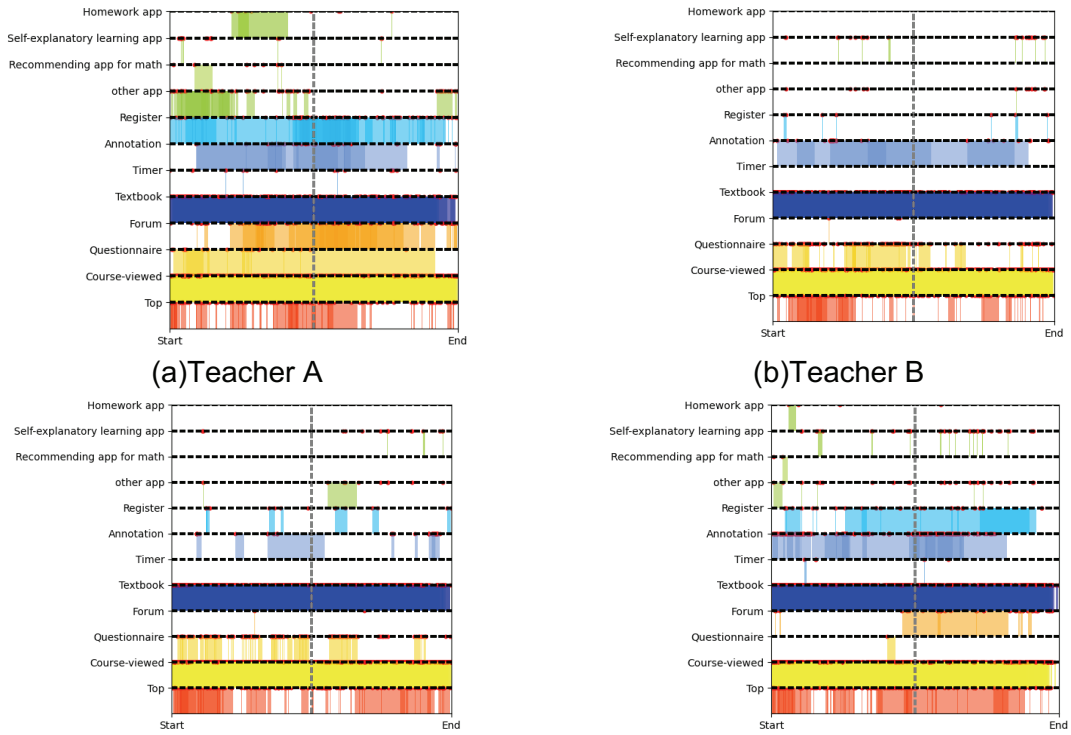
3.2 RQ2: Do instructional patterns differ depending on tool use experience?

Expanding upon our initial findings, we next explored whether teachers' experience with the LEAF system influenced their instructional patterns and methodologies. We delved into the profiles of four mathematics teachers at this junior high school. Teacher A, having been with the institution since 2010, assumed the role of teaching 3rd-grade mathematics in 2022. Meanwhile, Teacher B joined the institution and taught 2nd-grade mathematics in 2022. Teacher C has been a part of the institution since 2020, while Teacher D recently joined the institution in 2022, both teaching 1st-grade mathematics in 2022. Regarding their proficiency with the LEAF system, Teacher A stands out with four years of experience, followed by Teacher C with two years. Teacher B has years' experience, while Teacher D is relatively new, with less than a year of engagement. A comprehensive overview of these teachers' backgrounds is presented in Table 1.

Table 1. Four mathematics teachers

	Teacher A	Teacher B	Teacher C	Teacher D
Class	3rd grade	2nd grade	1st grade	1st grade
Position	senior teacher	Teacher	teacher	teacher
Assignment period	from 2010	from 2021	from 2020	from 2022
LEAF use experience	4 years	1 year	2 years	Less than 1 year

We aimed to visualize teachers' instructional patterns from daily teaching log data to understand their experience and familiarity with the LEAF system. We used the overlay method proposed in Figure 6. Figure 8 shows a visualization of all classes conducted during the specified period. In this case, Teacher A, who teaches 3rd grade, used learning analysis tools for a long time and tended to use them in the first half of the class (Figure 8(a)). Moreover, when compared to Figure 8(b), (c), and (d), it is apparent that Teacher A used multiple functions, such as forums and discussions during this period. These results suggest that the use of ICT tools changes as the school year progresses, resulting in the inclusion of diverse instructional methods.



(a)Teacher A (b)Teacher B

(c) Teacher C (d) Teacher D

Figure 8. Overlayed instructional patterns of each teacher in all classes

3.3 RQ3: Is there a difference in instructional patterns using ICT tools among the same subjects?

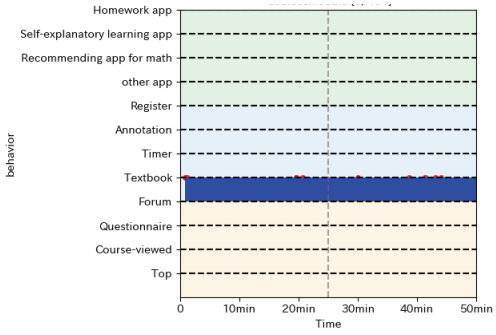
In our analysis of teachers utilizing various ICT tools in 75 classes, we analyzed the specific tools they specifically used. The breakdown of these 75 classes is as follows: Teacher A conducted 15 classes, while Teacher B classes conducted 13 classes. Additionally, there were 47 classes taught by teacher C and teacher D combined (Table 2).

Following the analysis of 75 classes, we identified two distinct categories in teachers' instructional patterns. Firstly, there were classes that solely utilized e-books (N=18, 24.0%). Secondly, there were classes using LMS and e-books (N=57, 76.0%). We then analyzed the differences in instructions using the proposed visualization method.

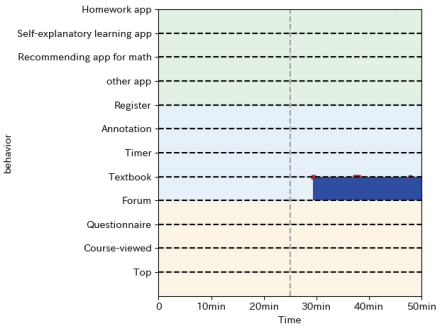
Table 2 shows the learning contents of 75 classes for the four mathematics teachers

Learning Units	Teacher	Number of classes	Duration
Shapes and Similarity (Textbook, pp.120-153.)	Teachers A	15	Mid-April - Mid May
Investigate Shapes (Textbook, pp.94-135.)	Teacher B	13	Mid-May - Mid-June
Proportion and Shapes (Textbook, pp.91-117.)	Teacher C	20	Early-June - Early September
Proportion and Shapes (Textbook, pp.91-117.)	Teacher D	27	Early-June - Early September

Figure 9 presents a case study of a class that exclusively used e-books. The Teachers' usage of e-book can be classified into two categories based on the timing of "textbook" use. The first pattern used the tool all the time during the class (N=14, 77.7%), as shown in Figure 9(a), and the other used the tool half the time (N=4, 22.2%), as shown in Figure 9(b).



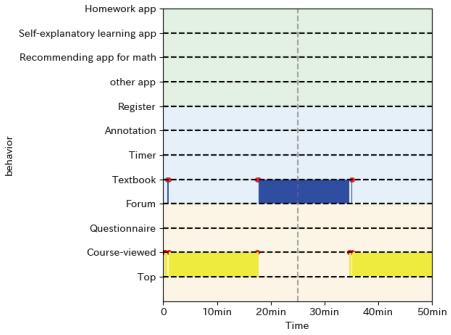
(a)All time
(teacher A, April 18th class)



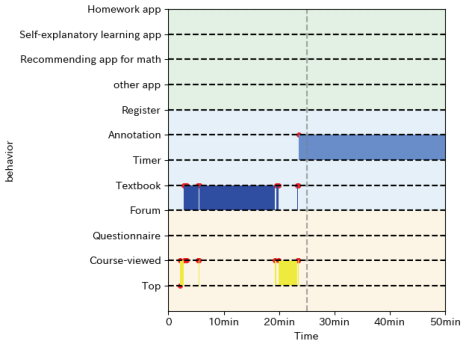
(b)Half of the class
(teacher B, Jun 20th class)

Figure 9. Classes use only e-books. (N=18 classes by four teachers)

In contrast, Figure 10 illustrates the categorization of classes that utilized both LMS and E-books. The analysis reveals that the majority of classes predominantly relied on two tools: “textbook” and “course-viewed” (N = 51, 89.5%), as demonstrated in Figure 10(a). However, a smaller subset, as presented in Figure 10(b), incorporated an additional tool, “Annotation”, resulting in the use of three distinct tools in total (N=6, 10.5%).



(a) two types of behavior (B2 and B5)



(b)three types of behavior (B2, B5 and B7)

Figure 10 Classes using LMS and e-books together (N=57 classes by four teachers)
(B2, B5, and B7 indicate the names of teachers’ behaviors shown in Figure 3)

4. Discussion

The study aimed to clarify the differences in class instruction using multiple systems to support teachers’ reflections on teaching practices for TPD. Through our analysis, we identified that the usage of ICT tools differs depending on the subject. However, there was a commonality in tool usage within the same subject. Furthermore, we observed that the usage and timing of ICT tools differed based on the experience and role of the teacher.

Reflection from experience and practice is important to promote behavioral change and decision-making and improve teachers’ professional skills (Prieto et al.,2020). However, in the context of analyzing teachers’ activities, the y focus has been on monitoring the students rather than closely observing teachers’ activities (Ndukwe & Daniel, 2020). Therefore, teachers have traditionally relied on questionnaires and videos to reflect on their practice. However, the method proposed in this research offers a novel approach that allows teachers to reflect on their classes without requiring any special preparation using ICT tools daily. This method also facilitates the sharing and discussion of teaching practices with others.

Essentially, this research supports teachers' reflections without the need for extensive preparation. Three key findings come out of this study.

(1) RQ1: What kind of ICT tools do teachers use to teach daily?

Our findings underscore the value of daily log data in understanding teaching practices. While our study did not delve into specific tools, it highlighted the variance in tool usage patterns based on teachers' backgrounds. It became clear that different teachers used the same system differently.

(2) RQ2: Do instructional patterns differ depending on tool use experience?

Research question 2 focused on four mathematics teachers and aimed to identify patterns in how teachers used ICT tools based on their tenure and role. To accomplish this, we employed the overlay method proposed in the study. The results indicated that senior educators, perhaps seasoned by their prolonged interaction with the system, seem to exhibit a broader repertoire in their teaching approach. Meanwhile, newer entrants appeared to be on a learning curve.

(3) RQ3: Is there a difference in instructional patterns using ICT tools among the same subjects?

In research question 3, we conducted an analysis of the usage of specific tools in 75 mathematics classes. Our research findings indicate that there are variations in teaching styles with the same subject. We can explore differences in teaching styles from extensive daily log data by using this visualization. By identifying the differences in teaching styles depending on the subject, teachers can focus on important differences in practices and reflect on them.

This study has certain limitations that should be acknowledged. Firstly, the identification of classes was based on rules, dates, and timetables extracted from log data. Additionally, the estimation of instruction types was also based on the log data. Moreover, the results of this study are limited to Japanese junior high school teachers. On the other hand, we have presented a method for visualizing xAPI log data. Therefore, this method has not yet been evaluated by teachers. In the future, we plan to involve teachers in the evaluation of the proposed method.

In the future, we intend to extend the proposed method to include other teaching materials and subjects. Teachers utilize various tools, such as ICT, to deliver the content of their subjects. Therefore, the use of ICT tools may vary depending on the specific content being taught. The proposed method has the potential to extract teachers' instructional patterns within the same subjects. By using ICT tools, it becomes possible to identify effective teaching methods through log data analysis.

5. Conclusion

In this study, we enhanced Nakamura et al.'s (2022) method to support teachers' reflections on class practice and clarify the differences in class instruction using multiple systems. By applying this method to the xAPI log data of Japanese junior high school teachers, we were able to visualize the tools utilized by the teachers across multiple systems. However, the Proposed visualization method was not evaluated, so we lack insight into how real teachers might use the visualization. In the future, it is necessary to present the results visualized by this proposed method to actual teachers and assess their effectiveness. By employing the proposed method, teachers can reflect on their daily use of ICT tools based on the logged data, which has the potential to improve their professional skills.

Acknowledgments

This study was supported by NEDO JPNP20006, JSPS KAKENHI JP22K20246 and JP23H00505.

References

Avalos, B. (2011). Teacher Professional Development in Teaching and Teacher Education over Ten Years. Teaching and Teacher Education, 27(1), 10–20.
Cherrington, S., & Loveridge. (2014). Using Video to Promote Early Childhood Teachers' Thinking and Reflection. Teaching and Teacher Education, 41, 42–51.
Hoyos, A. A. C., & Velasquez, J. D. (2020). Teaching Analytics: Current Challenges and Future Development. IEEE-RITA, 15(1), 1–9.
Kleinknecht, M., & Schneider, J. (2013). What do teachers think and feel when analyzing videos of themselves and other teachers teaching? Teaching and Teacher Education, 33, 13-23.
Nakamura,K., Horikoshi,I., and Ogata,H.(2022). Teaching Analytics across Multiple Systems: A Case Study at a Junior High School in Japan, Proceedings of 30th International Conference on Computers in Education (ICCE 2022). Asia-Pacific Society for Computers in Education (APSCE), Vol. 1
Koukis, N., & Jimoyiannis, A. (2019). MOOCS for Teacher Professional Development: Exploring Teachers' Perceptions and Achievements. Interactive Technology and Smart Education, 16(1), 74–91.
Lin, T., Nagpal, M., VanDerHeide, J., Ha, S. Y., & Newell, G. (2020). Instructional patterns for the teaching and learning of argumentative writing in high school English language arts classrooms. Interactive Technology and Smart Education, 33(10), 2549–2575.
Mangaroska, K., Vesin, B., Kostakos, V., Brusilovsky, P., & Giannakos, M. (2021). Architecting analytics across multiple e-learning systems to enhance learning design. IEEE Transactions on Learning Technologies, 14(2), 173–188.
Martínez, J. F., Kloser, M., Srinivasan, J., Stecher, B., & Edelman, A. (2022). Developing Situated Measures of Science Instruction Through an Innovative Electronic Portfolio App for Mobile Devices: Reliability, Validity, and Feasibility. Educational and Psychological Measurement, 82(6), 1180–1202.
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).
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.
Postholm, M. B. (2008). Teachers developing practice: Reflection as key activity. Teaching and Teacher Education, 24(7), 1717-1728.
Prieto, L. P., Magnuson, P., Dillenbourg, P., & Saar, M. (2020). Reflection for action: Designing tools to support teacher reflection on everyday evidence. Technology, Pedagogy, and Education, 29(3), 279–295.
Regueras, L. M., Jesus Verdu, M., & de Castro, J. (2022). A rule-based expert system for teachers' certification in the use of learning management systems. International journal of interactive multimedia and artificial intelligence,7(7), 75-81.
van Leeuwen, A., Rummel, N., & van Gog, T. (2019). What information should cscl teacher dashboards provide to help teachers interpret cscl situations? International Journal of Computer-Supported Collaborative Learning, 14(4), 261-289.