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Proposal of a Method for Analyzing Self-Regulated Learning Processes with Trace-Data of Learning Log from Digital Textbooks

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Abstract: SRL (Self-Regulated Learning) is currently the subject of much research. In our previous studies, there are systems (STELLA) that can accumulate learners' learning history in digital textbooks and systems (SELFY) that support SRL by providing feedback to learners on their learning history collected by STELLA. However, since the evaluation method is in the form of a questionnaire, the evaluation is inherently subjective and often lacks real-time behavioral insight. Furthermore, existing methods are frequently domain-dependent, making it difficult to generalize findings across different subjects. Therefore, this study addresses two primary issues: (1) reliance on subjective evaluations through questionnaires and (2) the domain-dependence of existing SRL evaluation methods. Our purpose is to propose a trace-based, domain-independent analysis method that overcomes these limitations and enables more objective evaluation of SRL processes using digital textbook data. In this paper, we propose a method for analyzing SRL processes with trace-data of learning log from digital textbooks.

Keywords: Self-regulated learning, digital textbook, trace-data

1. Introduction and Related work

In recent years, with the spread of LMS (Learning Management System), it has become possible to collect and store the trace-data of learners and analyze the data. Learning Analytics is one way to analyze this. This made it easier to treat and analyze the learner's detailed learning behavior as a history.

Self-regulated learning (SRL) is a process where learners set goals for their learning and then monitor, regulate, and control their cognition, motivation, and behavior, guided and constrained by a plan (Zimmerman, 1989). This is why academic researchers are increasingly looking for ways to measure student SRL behavior and, as a result, provide more effective support to help students engage in more productive SRL (Yizhou, 2022). The method to measure SRL processes is as follows: including self-reported questionnaires, think aloud protocols, and trace-data. Trace-data of learners can be treated as a history of the learner's behavior when using the digital textbook.

We proposed STELLA (Storing and Treating the Experience of Learning for Learning Analytics), a system for collecting learning history for digital textbooks. There is also a learner-s' SRL support system called SELFY (SElf-regulated Learning FacilitY) that visualizes STELLA's learning history and provides some feedback to learners. Currently, there is no way to evaluate SELFY except by questionnaire. Learning histories related to metacognition and low-level metacognition have been collected. However, they have not yet been analysis (Kikawa, 2024).

Ikenna et al (2024) researched how trace-data influence the extracted processes and analysis. However, their study is domain-dependent on performing a specific task (writing an essay). Therefore, action labels and SRL processes are also task-related indicators. Their study did not cover any task or domain except writing essays.

Similarly, Ogata et al (2025) utilized BookRoll-based log data and learning analytics dashboards (LADs) to enhance SRL in blended learning environments. However, their analysis focused primarily on coarse-grained metrics such as annotation frequency and reading time, without applying detailed, semantically-rich action labels grounded in SRL theory. In contrast, our study introduces domain-independent and theoretically-informed action labels to capture fine-grained SRL behavior across different subjects and learning contexts. These labels are designed to map directly onto phases of SRL such as planning, performance, and reflection.

Considering the above, we propose a domain-independent action label and index of the SRL process to analyze any subject from digital textbooks.

2. STELLA + SELFY

STELLA SELFY

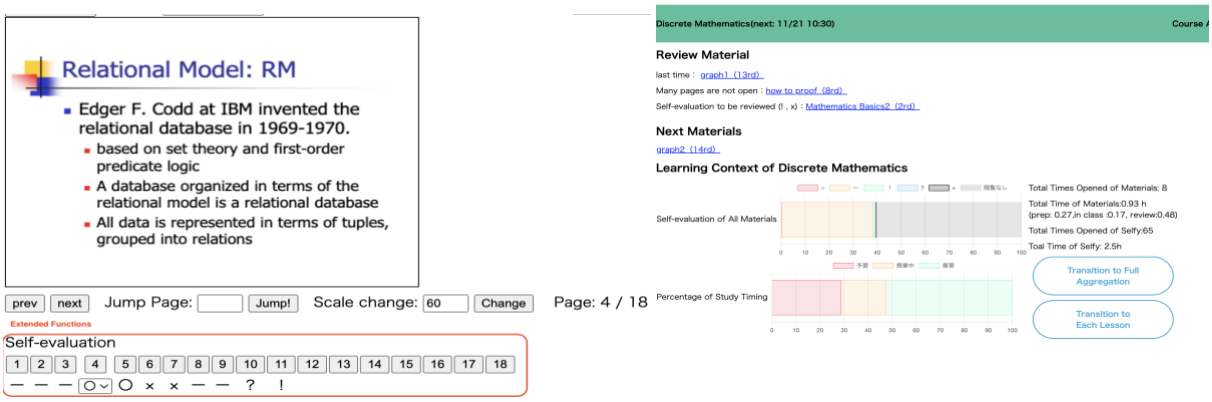

Figure 1: Interface of STELLA and SELFY

STELLA features include PDF viewing, writing on pages, sticky notes, and self-assessment, primarily supporting learning tasks. STELLA functions primarily as a viewer and viewing history can be collected in detail. However, High Cognition (HC: Elaborate by connecting content-related comments and concepts during reading or writing; Organizing of content by creating an overview; write down information point by in notes window; summarizing; adding information generated by oneself; and editing information by rephrasing or integrating information with prior knowledge.) activities such as note-taking are not considered STELLA. Therefore, we added a function to organize them in a note's function and a function to copy and paste keywords from a PDF document into the note's function and keep them as history, and to assign labels from HC activities.SELFY provides learners with a visualization of their learning history collected in STELLA to support SRL. Our prior research suggested that learners' use of SELFY increased motivation and supported SRL.

3. Proposal

Ikenna et al (2024) proposed that trace-and labeling is performed for the task of writing an essay, and SRL is evaluated. In contrast, this paper proposes a task- and domain-independent tracing and labeling method for the viewing history of a digital textbook viewer (STELLA) and the note's function corresponding to HC. Table 2 shows our proposal action label based on trace-data. The proposed action labels extend prior work by introducing domain-independent categories that can be applied regardless of subject matter. Unlike Ikenna et al (2024), whose labels were tied to a specific task (essay writing), our labels can capture SRL behavior in a variety of learning contexts. For example, the RELEVANT_READING label identifies when learners are engaging with core material for the first time, while NOTE_EDITING reflects metacognitive engagement through summarization or paraphrasing. These labels provide a foundation for interpreting learner activity across different instructional materials and allow for consistent analysis of SRL behavior.

We also propose a similar labeling method for SELFY viewing history to support SRL. Table 3 shows an objective evaluation of the learning history.

Table 2: Action Labels based Trace-Data

Action Labels	Action descriptions
GENELRAL_INSTRUCTION	Learners read or re-read general instruction and learning goals
RUBRIC	Learners read or re-read the rubric
RELEVANT_READING	Learners read and learn learning content for the first time
RELEVANT_RE-READING	Learners re-read and review for learning content which they have read before
IRRELEVANT_READING	Learners read the pages which are not relevant to the learning content
IRRELEVANT_RE-READING	Learners re-read the pages which are not relevant to the learning content
NAVIGATION	Learners navigate through pages or scroll at catalogue zone
COPY_PASTE	Learners copy and paste some content from reading materials into the notes
NOTE_EDITING	Learners create, delete, edit or label the notes
NOTE_READING	Learners click to open and read or re-read the notes
HIGHLIGHT_EDITING	Learners create, delete or edit the highlights
HIGHLIGHT_READING	Learners click to open and read or re-read the highlights
HIGHLIGHT_LABELLING	Learners create tags for highlights
SEARCH_CONTENT	Learners use the search tool on the left to search for learning contents
SEARCH_HIGHLIGHT_NOTE	Learners use the search tool search notes or highlights

Table 3: We add SRL action label to evaluate SRL support facility

SRL_RELEVANT_SELF-EVALUATION	Learners click to open and read or re-read the self-evaluation
SRL_IRRELEVANT_SELF-EVALUATION	Learners click to open and read or re-read the irrelevant self-evaluation
SRL_RELEVANT_EVALUATION	Learners click to open and read or re-read the evaluation
SRL_IRRELEVANT_EVALUATION	Learners click to open and read or re-read the irrelevant evaluation

This will lead to task- and domain-independent trace-data labeling from history to enable evaluation and measurement of SRL.

4. Conclusion and Future Work

In this paper, we proposed a domain-independent action label to evaluate whether SRL is supported from learner trace-data. Accordingly, we extended the functionality of STELLA and SELFY to collect learning history.

In future work, we need to develop tools to visualize the process of action labels and SRL. This visualization tool can be used for objective evaluation. To evaluate the system, we compare the results of the questionnaire format with the results of the analysis from the trace-data of learners to assess whether SRL was supported. We will use the expanded STELLA and SELFY with learners in the classroom and make comparisons along with a questionnaire. We also compare our subjective and objective results to assess whether SRL was supported. We will improve the action labels or expand the system depending on the results of our analysis. Furthermore, we plan to explore whether the proposed labeling method can be applied to other learning tools beyond STELLA and SELFY.

References

Zimmerman, B. J. (1989). A social cognitive view of self-regulated academic learning. *Journal of Educational Psychology, 81*(3), pp.329–339.

Yizhou F., Joep van der G., Lyn L., Mladen R., Jonathan K., Johanna M., Inge M., Maria B., and Dragan G. (2022). Improving the measurement of self-regulated learning using multi-channel data. *Metacogniton and Learning (2022)*, 17, pp.1025–1055

Kikawa T., Yamasaki M., Miyamoto K. & Mendori T. (2024). Development of a Learning Environment Supporting Self-Regulated Learning with Self-Evaluation. *Companion Proceedings 14th International Conference on Learning Analytics & Knowledge (LAK24),* pp.209-211.

Ikenna, O., Guanliang, C., Yizhou, F., Mladen, R., Shaveen, S., Inge, M. & Dragan, G. (2024). Measurement of Self-regulated Learning: Strategies for Mapping Trace Data to Learning Processes and Downstream Analysis Implications. *LAK24 Conference Proceedings*, pp.563-575

Yang, C. C. Y., Wu, J.-Y., & Ogata, H. (2025). Learning analytics dashboard-based self-regulated learning approach for enhancing students' e-book-based blended learning. *Education and Information Technologies, 30*(1), pp.35–56.