

Title	ICT活用教育におけるプロセス改善を目的とした学習者の 時系列行動分析
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## Abstract

The purpose of this study is to propose a framework for applying Learning Analytics (LA) to clustering learning process data of different granularity of active learning in ICT-enhanced education. It promotes instructors' "analytical activities" as a basis for Instructional Design (ID), a scientific approach to improving educational methods in which learners independently perform active learning tasks.

The spread of the COVID-19 in 2020 has forced a significant shift in traditional face-to-face education. To avoid the so-called "Three Cs," i.e., Closed spaces with poor ventilation, Crowded places with many people nearby, and Close-contact settings such as close-range conversations, not only primary and secondary education but also higher education have been forced to suspend face-to-face classes temporarily, and the effects are continuing in 2021. To improve this situation, online classes, which replace face-to-face classes with video conferencing systems or MOOCs, and hyflex classes, which allow learners to choose face-to-face or online classes flexibly, are being promoted. However, in these classes, it is more difficult for instructors to monitor and assess the progress of learners in remote settings than in the traditional way. Therefore, it is not easy to improve the educational content by grasping the status of learners through frequent formative evaluations, even though the summative evaluation through midterm and final examinations can be conducted.

Although the traditional face-to-face class style, based on teaching by the instructor and applying by the learners, is efficient in terms of knowledge transfer, many problems have been pointed out to guide them to a deeper understanding and establish skills such as "learning how to learn." For this reason, the introduction of active learning, which makes the learning process more active, is being recommended in the current educational scene. Since active learning consists of independent learning activities, it is difficult to assess the active learning results only by conventional examinations, and it is necessary to pay attention to the learning process. In addition, it is not easy for instructors to correctly grasp the status of each learner and improve the educational method because each learner has a different way of proceeding and trial and error with the target task.

ID is attracting attention as a practical approach for designing educational methods adapted to these new situations. Among the various methods of ID, the ADDIE model, which stands for Analysis, Design, Development, Implementation, and Evaluation, has been put into practice as a method of continuously constructing educational plans and materials as an educational process. Although many practices have been carried out,

there is no definitive method for analyzing the issues faced in specific educational processes, and it is often pointed out that appropriate analysis has not been conducted.

This study proposes a framework for analyzing educational process issues by using the LA approach for time-series data. Various data related to learners' learning processes are accumulated in online classes and active learning using ICT. There are various levels of time-series data that vary depending on the platform used for learning. For example, long-term data concerning the curriculum that students acquire from the entrance to graduation; mid-term data relating to the learning process of individual courses, such as attendance, exercises, and examinations; and short-term data including learning activities in each of the lectures.

In this study, the access logs of the lecture archive system at JAIST were first analyzed to focus on the learning process at the subject level. This system provides a form of the online learning environment. The target logs were 42,470 cases for four years from 2010. The number of lectures recorded during this period was 5,389, and the number of unique learners was 912. The access logs were anonymized, and clustering methods were applied to the time-series access logs and the learner's attributes, such as working students and international students. Based on these data, we visualized the time of day and period of use of the lecture archive system and the usage tendency of users, analyzed the usage style of the lecture archive system by students, and examined the issues for the next system update.

Then, analyses of the learning activities per lecture were conducted, especially the active learning process. Two experiments were carried out: a small-scale preliminary experiment with eight students and a regular class-scale experiment with 32 students. In considering the improvement of the learning process at this level, it is essential that the learning activities of individual learners occur more frequently and require more data. Therefore, to emphasize the improvement points, the instructors should pay attention to when implementing ID, the proposed method aims to promote the effective analysis process in ID by extracting characteristics through LA's data-driven analysis. Clustering groups of learners and presenting them to instructors might reduce the cost of their analysis phase. To achieve this, the PC screen changes were adopted to collect the learning process since it is independent of the application used for such learning. Since the learning process is a kind of human behavioral data, the dynamic time warping (DTW) method, often used in speech analysis, was applied to conduct flexible analysis. In this study, the usefulness of this method was confirmed to compress the amount of information required for analysis to make ID more effective.

In conclusion, the clustering methods were applied to two time-series data with

different granularity to highlight and visualize the characteristics of the system and learners. The framework to apply such the LA approaches to ID was also discussed to improve the educational process. In the analysis of lecture archives for large-span analysis, the results reconfirmed the significance of the system for providing video materials as supplementary materials in a sustainable e-Learning environment. In addition, the system was also used as a part of language support in learning that was not the original purpose of its development. By applying this point to the ADDIE model, it is expected that the lecture archive system will be updated more effectively. In the analysis of learning activities in a single lecture with small granularity, clustering by DTW provided valuable results for understanding the situation in active learning situations. Especially, time-series clustering is expected to help compress the viewpoint of analysis in ID by integrating the learning behavior of multiple learners.

**Keywords:** Learning Process, Instructional Design, Learning Analytics, Time-Series Clustering, Dynamic Time Warping