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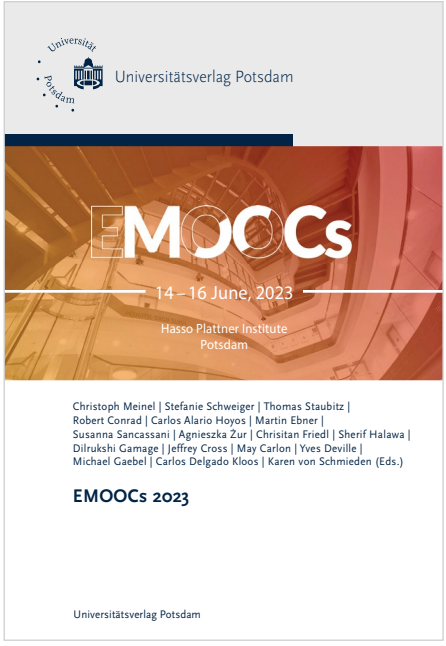

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Preparing for Society 5.0 with MOOC Capabilities Extension

An industry-academia collaboration on learning analytics dashboard development

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Academia-industry collaborations are beneficial when both sides bring strengths to the partnership and the collaboration outcome is of mutual benefit. These types of collaboration projects are seen as a low-risk learning opportunity for both parties. In this paper, government initiatives that can change the business landscape and academia-industry collaborations that can provide upskilling opportunities to fill emerging business needs are discussed. In light of Japan's push for next-level modernization, a Japanese software company took a positive stance towards building new capabilities outside what it had been offering its customers. Consequently, an academic research group is laying out infrastructure for learning analytics research. An existing learning analytics dashboard was modularized to allow the research group to focus on natural language processing experiments while the software company explores a development framework suitable for data visualization techniques and artificial intelligence development. The results of this endeavor demonstrate that companies working with academia can creatively explore collaborations outside typical university-supported avenues.

1 Introduction

Unlike outsourcing which focuses on reducing the costs of the client and the contracted party solely fulfills its contractual obligations, collaboration is more of an investment where the parties involved all seek to benefit from the partnership. Aside from the completion of a common project, collaborations can contribute to organizational learning and be a catalyst for innovation [1]. At Tokyo Institute of Technology (Tokyo Tech), academia-industry collaboration programs include company-sponsored research, accommodation for visiting researchers, consultations, and collaborative research, among others. Each of these partnerships regards one party as a provider of some sort; it may be a company funding an activity, or the university sharing its know-how.

Working on the assumption that companies will finance projects while universities make discoveries will potentially limit opportunities for small-to-medium scale industries with less capital for technological diffusion. In Japan, it was found that industry funding is not as efficient as competitive grants in generating inventions; but inventions from competitive grants find it tough to see widespread use [8]. As such, it is important to increase academic researchers' proximity to the industry – one way is to creatively seek collaboration opportunities by thinking beyond the well-established university infrastructure.

In this paper, a collaboration between a company and a university laboratory is discussed. The goal of the collaboration is for the company to build visualization skills using a technology set they have not previously used, and for the laboratory to speed up the web browser development needed for its research. The motivation behind the collaboration is first discussed in section 2, followed by what is already known before the collaboration that can help each interested party achieve their goal in section 3. The novelty in this work is highlighted in section 4, where the interested parties' relationship is that of equal footing and not benefactor-beneficiary, which is common in such collaborations, is clarified. The current status of the collaboration is described in section 5, where the eventual benefits for both parties are presented.

2 Motivation Behind the Collaboration

In 2016, the Japanese government laid out goals for achieving a "Super Smart Society" or Society 5.0, which pushes industries and universities to "establish a systemic virtuous cycle of human resources, knowledge, and capital for innovation [2]." In 2020, the Cross Lab at Tokyo Tech received a competitive grant for research that involves the creation of a learning analytics dashboard (LAD).

2.1 Japan's Society 5.0

A popular way of summarizing human socioeconomic evolution is by dividing human history into "ages" based on significant transformations that were introduced: for instance, the transformation of materials for the Stone and Agricultural Ages [7]. The Industrial Age, or transformation of industries, is seen to be composed of several revolutions where huge innovations are introduced: the first with machinery, the second with technologies such as railroads, the third with digitalization, and the fourth with automation [10]. However, many consider the Third and Fourth Industrial Revolutions to be introductions of not mere innovations but of transformation: the transformation of information, thus receiving the label "Information Age".

Following the four previous "societies" – Stone, Agricultural, Industrial, and Information – Japan anticipates the birth of Society 5.0 [2]. In this new age, a transformation is expected to occur in how humans interact with physical space and cyberspace. In the education field, Society 5.0 will most likely materialize from the availability of big data, partially spurred by the proliferation of massive open online courses (MOOCs).

2.2 Learning Analytics Dashboards

LADs are interfaces showing multiple data visualizations aimed to provide information about learning experiences. The creation of LADs for MOOCs is attractive due to the availability of multimodal data that become more valuable to the learning experience after analysis and visualization. LADs have been instrumental not just in giving performance feedback but in providing motivation that is crucial to self-regulated learning [6], which in turn leads to better outcomes in online learning environments. With the availability of global data from MOOCs that attract learners around the world, LADs can even potentially be conduits for alleviating justice, equity, diversity, and inclusion concerns through more critical user need analysis and cross-border collaborations [12].

3 Prior Work

To stay abreast with the aforementioned trends, it is imperative to be conscientious in building research software and fostering continuous learning in the workplace.

3.1 On-the-job Skills Acquisition Strategies

On-the-job skills acquisition can be thought of as at least any of the following [9]:

- **New hire training** where new members of the company (including interns) receive orientation associated with the roles that they would be assuming in the company,
- **Project-based training** where a team picks up a skill to fulfill the requirements of their projects,
- **Upskilling** where an employee develops new skills related to their job for upward mobility in their career, and
- **Reskilling** where new skills are acquired in anticipation of significant changes in the workplace such as digitalization or automation.

Aside from reskilling, all of the above is somewhat commonly encountered in workplaces. However, reskilling is crucial for any company to remain competitive: in 2022, about a third of the anticipated essential skills for 2025 are not yet considered to be crucial [9]. With such a quick pace, reskilling efforts such as in this endeavor described in section 4 is more of a requirement than an option.

3.2 Personalized Online Adaptive Learning System (POALS)

POALS is a web-based system designed to help learners succeed in online learning environments. An overview of the system made up of three components – Metacognitive Tutor, Adaptive Engine, and Analytics Dashboard – is seen in Figure 1.

Metacognitive Tutor Metacognition, colloquially defined as "thinking about thinking," is essential to succeed in online learning environments. An existing metacognitive tutor was adapted to be more optimized and usable for online use, which is now POALS' Metacognitive Tutor. However, while the participants in the experiments rated the tutor to be usable and improvements in cognition regulation are observed, there is no clear indication that the tutor helps to achieve better learning outcomes [5].

Adaptive Engine The Metacognitive Tutor's lackluster results could be due to metacognitive training on top of cognitive learning straining the learners' cognitive resources. POALS' Adaptive Engine was envisioned to investigate cognitive adaptive learning for the Metacognitive Tutor [3]. Through initial investigation for Adaptive Engine, it was seen that models using metacognitive inputs performed better than the standard models while still following learning intuitions.

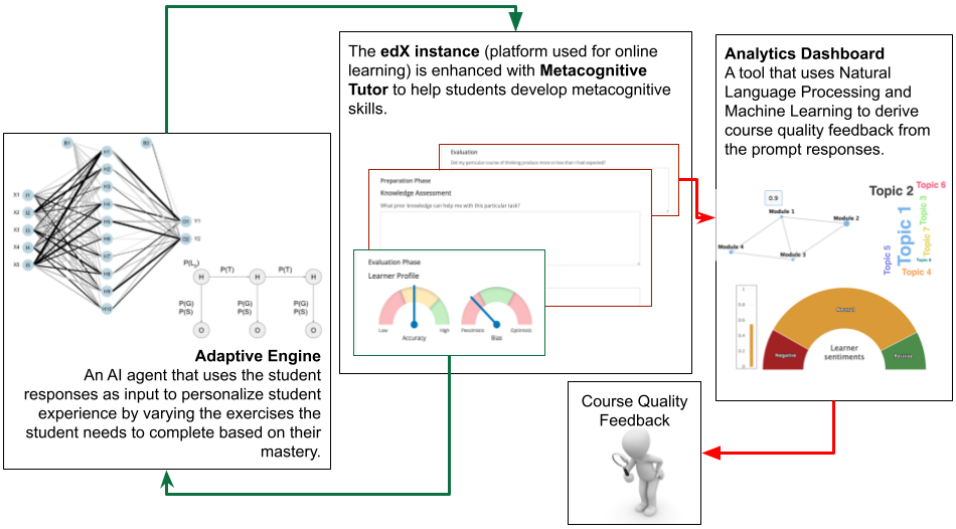

Figure 1: POALS overview.

But before fully implementing the Adaptive Engine, other issues surrounding it such as explainability will still need to be investigated.

Analytics Dashboard Finally, POALS' Analytics Dashboard is a visualization tool based on various natural language processing (NLP) techniques that serve as the teacher's window to their learners' implicit feedback. Learner inputs on the Metacognitive Tutor are used for the analysis. The proof-of-concept shows an aggregate of tools the teacher can use to understand learner sentiment, diagnose possible misconceptions, and check learning retention [4].

4 The Collaboration Project

With the current advancements in NLP research, it was determined that exploring the Analytics Dashboard's potential could be worthwhile. This collaboration project is between Wisdom Inc., a small-to-medium sized company in West Tokyo specializing in web and enterprise software and Cross Lab who had been working on MOOC-related research through their relationship with the Online Content Research and Development section under the Center for Innovative Teaching and Learning.

4.1 Project Organization and Learning Goals

As a company that has gained the trust of its Japanese clientele not just with development work but with business know-how as well, Wisdom Inc. is looking forward to learning new technologies that can be easily aligned with Japan's Society 5.0 goals. This includes web frameworks that can easily integrate with computational tools important for artificial intelligence development. Visualization techniques are also crucial especially as big data becomes more and more prevalent.

Cross Lab, on the other hand, is ramping up its personalized learning research. Aside from developing its research competency, it is imperative for the group to create a research ecosystem that not only allows for more research to happen but can also translate meaningful research outputs to practice that the public can benefit from. POALS is envisioned to be one such system.

In this project, Wisdom Inc. is improving the Analytics Dashboard while learning new technologies associated with a more computational-ready programming language and a data visualization library. This supports Cross Lab in building a long-term research project.

4.2 Improvement Points for the Analytics Dashboard

The Analytics Dashboard relies heavily on the Metacognitive Tutor for its input, but experiments using the Metacognitive Tutor did not indicate optimal results [4]. The preliminary studies on the Analytics Dashboard have promising results though, hence its development is worth continuing. Another difficulty is that as a Japanese institution, Tokyo Tech creates courses in both English and Japanese. Different languages will require different NLP techniques. Also, aside from edX.org, Tokyo Tech uses other LMS such as Moodle and Canvas for small private online courses (SPOCs). Of course, sharing POALS with other researchers working on MOOCs is of interest. Finally, the Analytics Dashboard is static and does not provide the teachers the opportunity to interact with the analysis. To address these concerns, the Analytics Dashboard was first modularized to separate the user interface from the data management and the data analysis. This modularization is illustrated in Figure 2 with each component described below.

Data Importer Instead of learner inputs from the Metacognitive Tutor, posts from discussion forums will be used for the Analytics Dashboard. edX.org has edX Data Package where various data associated with the learning management system (LMS) are collected, including forums database exports. POALS is created with the Python web framework Django, hence scheduled tasks importing data from LMS to the POALS ecosystem are managed with the task queue and

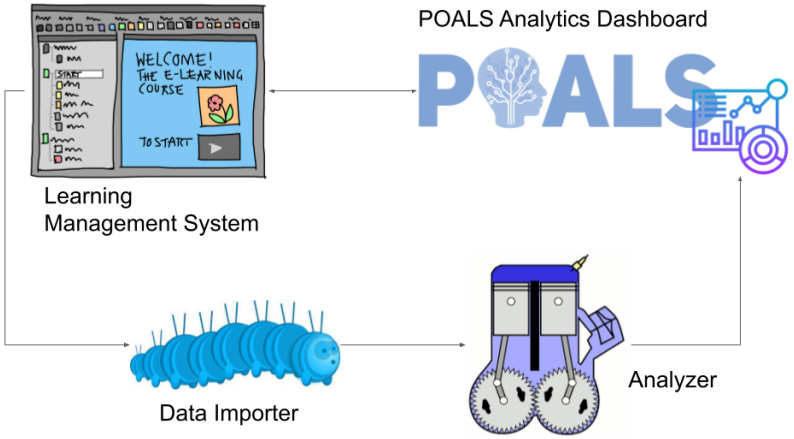

Figure 2: Modularization of the POALS Analytics Dashboard. Images from Pixabay, Publicdomainvectors.org, Flaticon, and Wikimedia Commons.

scheduler, Django Q. Aside from discussion forums, other text data such as course content may also be imported into the system.

Analyzer The NLP-based analysis from the original Analytics Dashboard is kept. Previous source codes associated with NLP processing are converted instead into a Python package. This allows researchers to test out their analyses in Jupyter notebooks and the like using their test data and making changes to the package as they see fit. This benefits the collaboration as the company can continue with the web application development without disrupting the ongoing research.

Dashboard The Analytics Dashboard's visualizations are created with Highcharts, a JavaScript library. With this, the teacher can have an idea of their learners' feelings and understanding of the lessons granted the resulting analytics is straightforward. However, automatically generated information may not be easily understandable, requiring the teacher to look into the summarized data's details and possibly make configuration settings. This is made possible in the new Analytics Dashboard as discussed in subsection 5.1.

5 Current Status

Collaboration talks started as early as December 2021, though the bulk of the work involved with the project peaked in February 2023. While the software itself is close to completion, the associated research is expected to continue. Further collaboration might be considered depending on the research progress.

5.1 The Improved POALS Analytics Dashboard

A sample user interface of the main dashboard is shown in Figure 3. Each of these parts is discussed in the succeeding paragraphs.

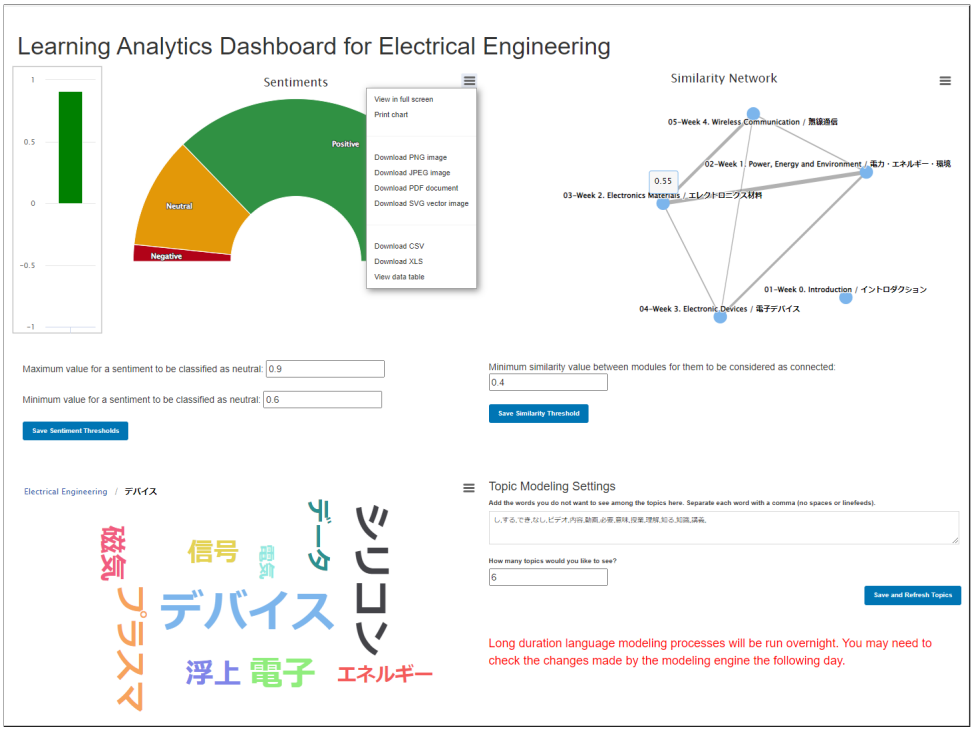

Figure 3: Sample user interface of the new dashboard.

Sentiment Analysis The Analytics Dashboard presents sentiment analysis in bar and donut charts, as shown in the upper left corner of the screen. The bar chart shows the overall class sentiment (higher scores generally mean more positive learners). A donut gauge shows the percentage of negative, neutral, and positive responses. This feature had been present in the original Analytics Dashboard.

In this updated version, the posts in the discussion forums are used instead of the learner responses in the Metacognitive Tutor. Aside from the change in the analytics source, clicking the bar chart will now display a line chart of average weekly sentiment scores in a modal dialog. Clicking on the donut chart will show the text data and the sentiment scores in tabular form. The teacher can adjust the sentiment score as they see fit. After manually editing the sentiment score, the chart values are immediately recalculated and redisplayed. Depending on the configuration, a new sentiment model will be trained asynchronously to use the updates made by the teacher. This allows us to anticipate problems posed by model drift, or the degradation in the model's ability because of the changes that have happened in its environment.

Text Similarity In the upper right corner of the Analytics Dashboard, a similarity network is displayed with a node for each course module. Hovering over a module will show the average learner score for that module. Similar modules based on some threshold value are connected by lines, and the degree of similarity between the modules is indicated by the thickness of the line (the thicker the line, the more similar the modules). This similarity is calculated based on the words used in the modules, including those in video transcripts, text on quizzes, and others. This visualization is useful for diagnosing when learners start forgetting important information in previous modules. This is also a feature that already exists in the original Analytics Dashboard.

In the updated version, teachers should be able to determine the similarity score threshold for connecting modules. Changing the threshold will immediately change the display. Clicking on a node will show a histogram of the grade data for that module.

Topic Modeling At the bottom of the Analytics Dashboard, the topics most frequently mentioned by the learners are displayed in a word cloud. Knowing which topics learners talk about can indicate which topics stick with them. If the class performance in a module associated with a topic displayed is generally good, then there is a good reason to believe that the topics are well understood. If a topic that appears in the word cloud is related to a module where the average score is low, then the module may have been misunderstood

by learners. Just like the sentiment analysis, the topic modeler uses the learner inputs in the Metacognitive Tutor in the original Analytics Dashboard.

Likewise, the information source for the topic modeler was changed to the discussion forum posts. Additionally, clicking on a topic will show another word cloud corresponding to the clicked topic, thus allowing drill-down analysis. Also, the teacher can change the number of topics the same way they are able to change the words to be ignored during modeling in the past. A message informing that the changing configurations will require model training that can take time to be completed will be displayed.

5.2 Learning Reflections

During the entire time of this collaboration, the Tokyo government has maintained its encouragement to businesses to be prudent about their work practice in order to avoid the spread of the coronavirus while working towards a new normal. In response to that, Wisdom Inc. has mostly maintained its remote work practices. This enabled the new hire assigned to this project to practice independent learning through official Django tutorials in Japanese. The new hire and the researcher have also conducted regular online live coding sessions to augment independent learning. The focus is not just on completing the software but to gain confidence in the learner's new technological know-how. This also helped in building the researcher's mentoring skills.

The learning actually started even before the bulk of the work started. Members at the mid-level learned from their seniors how to establish rapport with new business partners. Everyone on the team also learned about the intricacies associated with academia-industry collaborations in terms of bureaucracies. There were also several opportunities to learn from both sides about their respective endeavors outside the project being established. More interestingly, even though both sides have considerable multicultural experience, this collaboration still introduced novel experiences on that front. This allowed Wisdom Inc. to interact with non-Asian nationals and Cross Lab to be more bilingual (English/Japanese) in their operations.

6 Conclusion and Future Work

The POALS Analytics Dashboard was updated by Wisdom Inc. to allow the Cross Lab to have a system ready for further NLP-based research with MOOC data. This has been a valuable opportunity for the company to learn technologies making them more prepared for Society 5.0 demands and for the lab in creating software

that can potentially be used outside controlled experimental environments. This unique collaboration, where both parties are relative novices in the roles they are assuming, can be an inspiration for other companies and research groups who are looking to expand their current set of capabilities but may be hindered by less capital, may it be financial or social.

Testing and development are expected to continue until June 2023. The use of the Analytics Dashboard may be considered initially for SPOCs in 2024 after user research. Equally important is objectively analyzing the success of this collaboration [11].

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