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Tracking Learning Process on The ICE Model in A Flipped Classroom at A Japanese University

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Abstract: In this paper, we present the results of an analysis of text data written on digital MANDALAs by students in the course on the fundamentals of the Universe offered at a Japanese university. We designed the course based on the ICE model and implemented it in a flipped classroom. We identified students' learning processes in I, C, or E by verbs and analyzed them with KH Coder. We observed statistically that students' learning transitioned from I to C or E in their thoughts from the first week to the last week of the course. To track the learning process more accurately from the context, we fine-tuned BERT with classified data in I, C, and E, and achieved a classification accuracy of 78%.

Keywords: Learning process, Flipped classroom, ICE model, KH Coder, BERT

1. Introduction

We have been analyzing assignments and other materials submitted by students to improve the course (Aoki et al. 2022, 2024), which leads to independent learning based on the ICE model developed by Dr. Sue Young in Canada (Young & Wilson, 2000). In this paper, we present the results of our analysis of the practice of flipped classrooms and the tracking of the learning process for a course on the fundamentals of the Universe, designed based on the ICE model, for all undergraduate students at a Japanese university. In the ICE model, the learning process is divided into I (ideas), C (Connections), and E (Extensions), and learning progresses iteratively from I->C->E->I->... We believe it is important to transition from the I stage, in which learning is limited to the knowledge provided by the instructor, to the C and E stages, in which students broaden their perspectives and deepen their understanding through group work, presentations, discussions, and other activities. In the ICE model, which stages a student is classified with verbs (Dr. Young, personal communications, who is the developer of the ICE model). Thus, we take a change in the ratio of sentences classified as I, C, and E with verbs throughout the course as an indication of the transition in the learning process. In this paper, we introduce the transition in the number of sentences classified as I, C, or E, using verbs that students summarized their thoughts before and after classes.

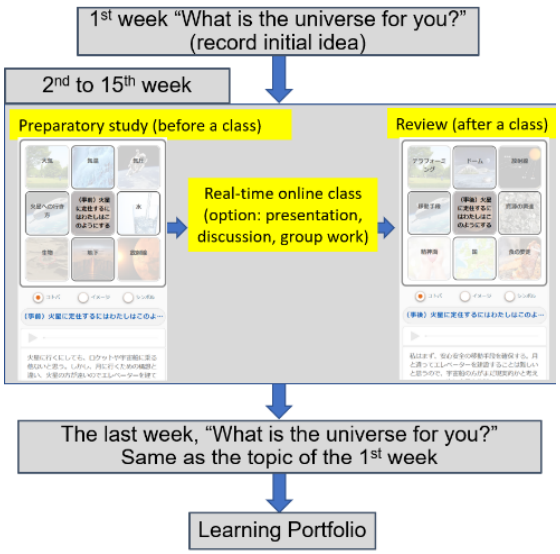

Figure 1. Working Flow of the Course

2. Course Design and Tools

We designed and implemented a flipped classroom based on the ICE model. In this course, students work in the following sequence (Figure 1). In the first week and the last week, students organize their thoughts on the theme: "What is the universe for you?" Students summarize their thoughts on several themes, such as "How to live on the Moon?" and "How to live on Mars?" from the 2nd week to the 15th week through activities like preparatory study, group work, and review. The student writes a final Learning Portfolio reflecting on their learning, accompanied by evidence related to the activities they have completed. We analyzed the descriptions of their thoughts in the digital MANDALA (see below) as textual data put at the activities.

We used the following tools for the practice and analysis: 1. Digital MANDALA 2. KH Coder. Digital 3. Google Colab

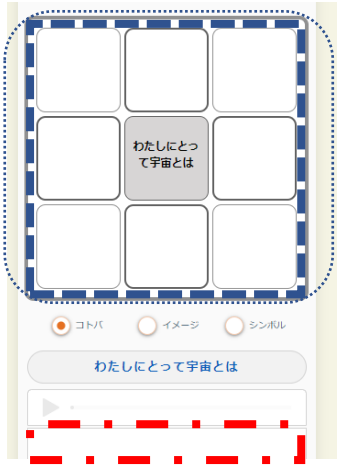

Figure 2. digital Mandala

Digital Mandala is our collaborative creation platform that supports individuals and groups in organizing and visualizing their thoughts. In the course, students use the digital MANDALA to compare, categorize, and combine group members' thoughts. Then, a representative of the group gives a presentation and discusses it among class students. In digital MANDALA, students put eight short sentences in outer cells (the dashed box in Figure 2), which represent their thoughts on the theme in the center cell. Then, describe their thoughts with sentences put into the bottom field (single-dotted dashed box in Figure 2).

Initially, we analyzed the sentences entered at the bottom of the digital MANDALA using the KH Coder (Higuchi et al. 2007), an application for text analysis. We offered the course in the fall semester of 2023 to 21 students from the College of Arts and Sciences who had enrolled for various years. Next, we fine-tuned a general pretrained model, “BERT,” on the Transformer technology of AI, enabling sentences to classify automatically into I, C, and E categories based on context. We used Google Colab for this task.

3. Results and Analysis

In order to statistically determine whether students' thinking shifted toward C and E rather than I in the ICE model throughout the course, we assigned the following verbs to I, C, and E. Then, using the coding function of KH Coder, we calculated cross tabulation of the texts written in digital MANDALA on the same theme, "What is the universe for you?" in the first week and the final week (Figure 3).

I: Know, hear, learn, read, recognize, or read

C: Connect or engage

E: Change (in thinking, impression, recognition, or perspective), become able to do, notice, become aware of, or come up with an idea

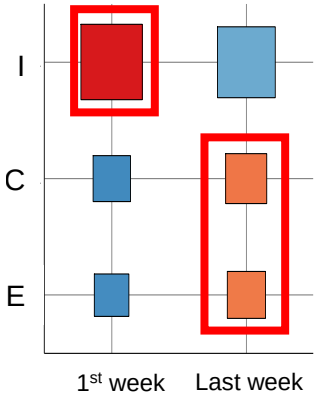

Figure 3. Cross tabulation

The results of the analysis are shown in Figure 3. In Figure 3, the labels on the vertical axis are I, C, and E, and the horizontal axis is "1st week" and "last week." The size of a rectangle corresponds to the occurrence rate, with warmer colors indicating stronger correlations than cooler colors. Thus, the number of sentences in which the verb corresponding to I has a stronger correlation with "1st week," and the number of sentences in which the verb corresponding to C or E has a stronger correlation with "last week" (red box in Figure 3). However, the correlations are not statistically significant. The reason may be that the total data is small (173 sentences), and the number of sentences in which the verbs corresponding to I, C, and E are even smaller. As a result, there was a transition from I to C and E throughout the course since the

correlation with I was strong in the first week, but by the last week, the correlation with C and E was stronger.

Since verbs change meaning depending on their context, it is not easy to determine whether they belong to the I, C, or E category. Therefore, we decided to fine-tune the general pre-trained model BERT so that it can automatically classify sentences into I, C, or E based on context, enabling us to capture changes from I to C or E through the course. We chose BERT because it performs well in classification, considering its computational cost.

As additional training data, we used the text entered by students in the description field of digital MANDALA regarding the theme "What is the universe for you?" from the spring semester of 2023 to the fall semester of 2024 (four semesters) and regarding the theme "How to live on the Moon?" and "How to live on Mars?" from the spring semester and fall semester of the 2024 (two semesters). We reviewed all the data, classified into I, C, and E based on context, to use as labeled data for fine-tuning BERT (bert-base-japanese-v3).

The number of characters in the data classified as I, C, and E are as follows.

I: 186,368, C: 270,336, E: 282,624.

As a result, we got fine-tuned model with classification accuracy of 78%. Our goal is to improve the course by tracking changes in the learning process, specifically in the proportions of I, C, and E, throughout the courses. Therefore, we need to improve the model's accuracy. To that end, we plan to incorporate data that has not been utilized for additional learning to enhance accuracy. We are also considering using a pretrained model with a large number of parameters.

4. Summary

In this paper, we present the results of an analysis of text data written on digital MANDALAs by students in the course on the fundamentals of the Universe offered at a Japanese university. We designed the course based on the ICE model and implemented it in a flipped classroom. The course consists of preparatory study, group work, and review. Students describe their thoughts on several topics in the digital MANDALA, give presentations, discuss, and finally write learning portfolios to reflect on their learning.

We identified students' learning processes in I, C, or E by verbs and analyzed them with KH Coder. We observed statistically that students' learning transitioned from I to C or E in their thoughts from the first week to the last week of the course. To improve the classification accuracy of I, C, and E based on the context, we classified the text in the description field of digital MANDALA into I, C, and E as labeled data and fine-tuned BERT. As a result, we achieved a classification accuracy of 78%. To improve accuracy, we plan to use unused data and are also considering using a pre-trained model with a large number of parameters.

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