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Analysis of Practical Examples of a Real-time Online Class on Agriculture in Space, Using the Collaborative Learning Tool "Digital Diamond Mandala Matrix"

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Abstract. The effectiveness of our "digital Diamond Mandala Matrix (dDMM)" application on a real-time online class is shown based on the results of analysis of output by students. The dDMM application which is something like a mind map limiting words to nine plus a description field for explaining the whole of the dDMM data. We can easily view several dDMMs at a glance for comparing them with each other, so it is highly suitable for an online class where only one screen can be shared. In order to improve the effect on students' learning, the class was offered in an active learning style, so that it consists of pre-learning, a real-time online class with a lecture, and discussions based on the pre-learning using Zoom Meeting, and students' re-thinking based on the online class as post-learning. Students input data into the dDMM application as pre-learning dDMMs before participating in the online class, and then join the class consisting of a lecture and discussions based on the pre-learning dDMMs. They input data into the dDMM application as post-learning dDMMs after the online class. In order to investigate the efficacy of the dDMM application on real-time online class, we compared them statistically using the text data analysing tool KH Coder pre-learning and post-learning dDMMs, which are outputs by students. From the results, we found that post-learning dDMMs are improved from pre-learning dDMMs due to the lecture and discussions in the online class. Therefore, the dDMM application is an effective tool in real-time online courses. We will improve the application by adding functions such as automatic grouping for supporting collaborative learning, with multilingual support.

Keywords: Online class, Diamond Mandala Matrix, text analysis, KH Coder

1 Introduction

The results and its analysis of a real-time online class using our collaborative tool "digital Diamond Mandala Matrix (dDMM)" are shown. The class was part of the course "Agricultural Informatics in Next Generation" (instructor: Takahiko Naraki, lecturer: Seiichiro Aoki, director: Shinzo Kobayashi, number of students: 50) offered in Japanese at The Kyoto College of Graduate Studies for Informatics (KCGI) in the Autumn semester of 2020. In order to improve the effectivity on students' learning, the class was

offered in an active learning style. The class consists of pre-learning, a real-time online class with lectures and discussions based on the pre-learning, and students' rethinking based on the online class as post-learning.

In Japan, Diamond Mandala Matrix is sometimes used as a framework to realise "total optimisation of business and systems" in Enterprise Architecture (EA), which has been mainly worked on by the Ministry of Economy, Trade and Industry (METI). The advantage of DMMs is that cells are limited to up to nine [1] (comparable to a dotted line rectangle in Fig. 1a), so we can see all of the cells in a DMM at a glance. We thought DMM is highly suitable for online classes, so we have been developing a dDMM application inspired by DMM. In the class, we used the dDMM application for pre-learning and post-learning of students. In order to investigate the effectiveness of the dDMM application on a real-time online class, we compared and analysed the statistical output by students such as pre-learning dDMMs and post-learning dDMMs. dDMM data are text type data, so the analysis was performed using the free text analysing tool "KH coder" [2] as the first step of analysis. A similar analysis using KH Coder was performed by Aoki et al. (2020) for the answers to the questionnaire taken in astronomy lectures [3].

The dDMM application has been developed as a collaborative learning tool inspired by DMM. The dDMM application is used before a real-time online class consisting of lecture and discussion as pre-learning dDMM, and after the class as post-learning dDMM. The structure of dDMM can be seen in Fig. 1a. In the nine cells at the top (dotted line rectangle in Fig. 1a), a student input words in the surrounding eight cells and representative phrase in the central cell. In the three middle cells (dashed line rectangle in Fig. 1a), SDGs (Sustainable Development Goals) related to words in dDMM are selected. The bottom field (single dashed line rectangle in Fig. 1a) is a descriptive field for explaining the whole of the dDMM using words in the top nine cells. So, dDMM is something like a mind map that limits the number of words up to nine, extended with SDGs labels and descriptive fields. SDGs labels were setup because the course was related to sustainable society. And the dDMM application is highly suitable for an online class, where a single screen only is shared using an online conference

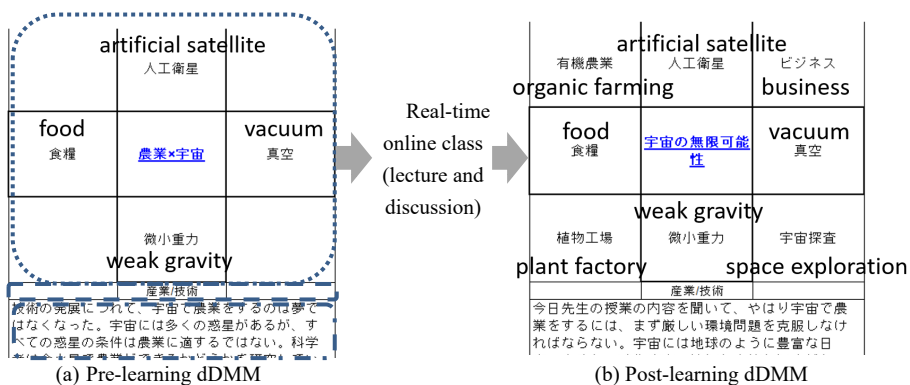


Fig. 1. Examples of dDMMs created by a student. (a) Pre-learning dDMM. (b) Post-learning dDMM. A student creates a pre-learning dDMM before real-time online class and post-learning dDMM after the class.

system. We can easily compare several DMMs through discussion, whenever only one screen can be shared using an online conference tool such as "Zoom Meetings".

In this paper, we show the effectiveness of the dDMM application on a real-time online class, by comparing pre-learning and post-learning dDMMs statistically.

2 Structure of Online Class

The main theme of the course was "Thinking about Sustainable Agriculture and Community". In the course, "Agriculture \times Something = Sustainable Society" was set as the common theme (target scope) for all classes. Based on the target scope, we set up a subdivided scope (topics related to the target scope) in each class session. The scope of the class for analysis was "Agriculture \times Space = Sustainable Society".

The classes consist of pre-learning, real-time online classes (lecture and discussion) and post-learning (see Fig. 1).

1) (Pre-learning) Each student found words related to agriculture in space by referencing websites, books or papers supplied by the lecturer, and input them in eight cells surrounding the central cell at the top of dDMM (see Fig. 1a). The phrase in the central cell was set to "Agriculture \times Space," which was common to all students. In the bottom field, students input sentences explaining whole of the dDMM. Here, the pre-learning dDMM was completed. These tasks were done by each student before attending the real-time online class.

2) (Real-time online class) The real-time online class was offered using a Zoom Meeting. The first half of the class was a lecture, explaining the Sun, Mars, Europa, Enceladus, and other satellites and exoplanets, especially from the perspective of agriculture in space. In the second half, discussions were held on the subject of pre-learning dDMMs (lecturer: Aoki, facilitator: Naraki, director: Kobayashi).

3) (Post-learning) On the basis of the real-time online lecture and discussions, each student created a post-learning dDMM by investigating words related to agriculture in space one more time. In the central cell at the top, each student thought up a phrase that represents the words in the surrounding cells. The results of the analysis of the central cell will be shown in another paper.

In order to offer the classes, we used the following tools.

(a) digital DMM (dDMM) application: It can be used on a browser, so students can use it with either a PC or a smartphone.

(b) Online conference system: Zoom Meeting is used for real-time online classes.

(c) Learning Management System (LMS): dotCampus of KCGI was used to share course materials.

3 Results of Analysis Applied to dDMMs

dDMM data for pre-learning and post-learning created by a student are shown in Fig. 1. At the bottom field of the post-learning dDMM, we can see that "after hearing the lecture today, I understood that we must first overcome the harsh environment in order to farm in space" (see Fig.1b). The overall difference between the pre-learning and the

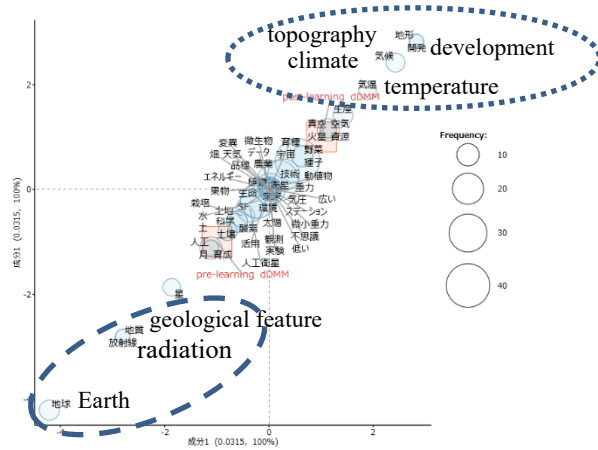


Fig. 2. Correspondence analysis diagram of the words in the surrounding eight cells of the central cell at the top in the dDMMs. Words that appeared four or more times are used. The words in the lower left (dashed line ellipse) are those that appeared more times in the pre-learning dDMM relative to post-learning dDMM. The words in the upper right (dotted line ellipse) are those that appeared more times in the post-learning dDMM relative to pre-learning dDMM.

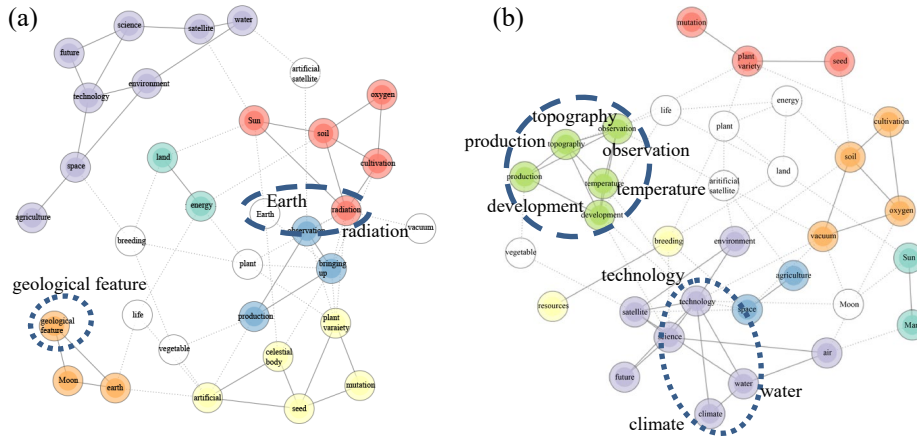


Fig. 3. (a) The co-occurrence network diagram of words in the surrounding eight cells at the top of the pre-learning dDMM and (b) that of the post-learning dDMM. The minimum number of appearances of a word is set to three. The darker the connecting line, the more students entered the words into the cells at the same time.

post-learning dDMMs is shown in the correspondence analysis diagram of words in the surrounding eight cells at the top (see Fig. 2). In the pre-learning dDMM, "Earth," "radiation," and "geological feature" are more common, while in the post-learning dDMM, "topography," "development," "climate," and "temperature" are more common. From these characteristics, the perspectives of students about agriculture in space before attending the online class were with a point of view of an Earth-centered mind and the

effects of radiation and geological feature, whereas after the class students got a broader perspective such as "climate," "temperature," "topography," and "development".

The co-occurrence network diagrams of words in the surrounding eight cells around the central cell at the top of the pre-learning dDMM and post-learning dDMM are shown in Fig. 3a and Fig. 3b, respectively. The connected words with lines are those which students put into the surrounding cells at the same time. Comparing Fig. 3a and Fig. 3b, we can see that the number of students who entered "Earth" and "radiation" (see dashed line ellipse in Fig. 3a) and "geological feature" (see dotted line ellipse in Fig. 3a) at the same time in the post-learning dDMM is decreased, because they are not appeared in the post-learning dDMM. On the other hand, the number of students who entered "topography" and "observation," "temperature," "development," or "production" (see dashed line ellipse in Fig. 3b) at the same time is increased. And the number of students who entered "climate" and "water" or "technology" (see dotted line ellipse in Fig. 3b) at the same time is also increased.

The overall trend of differences between the pre-learning and the post-learning dDMMs also can be seen in the correspondence analysis diagram of word in sentences in the bottom field of dDMMs (see Fig. 4). In the pre-learning dDMMs, "other" (other stars, other planets), "vegetable," "mutation," "growing," "science," etc. are more common, while in the post-learning dDMMs, "outside" (outside stars, outside planets, etc.), "growth," "water," "breeding," "necessary," etc. are more common. From these characteristics, it can be seen that before the online class, the students were aware of the genetic "mutation" of organisms due to the effects of radiation, and the use of "science" to "grow" crops such as "vegetables", while after the class students became to be aware of the active use of "breeding" and the "necessity" of "water" for "growth".

The differences are probably due to the fact that the lecturer took Mars as an example in the real-time online class, showing the low temperature and severe climatic

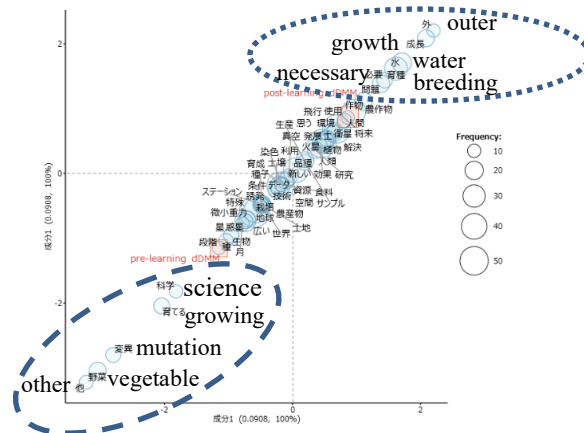


Fig. 4. Correspondence analysis diagram of the words entered in the bottom cell of the dDMMs. Words that appeared ten or more times are used. The words in the lower left (dashed line ellipse) are those that appeared more times in the pre-learning dDMM relative to post-learning dDMM. The words in the upper right (dotted line ellipse) are those that appeared more times in the post-learning dDMM relative to pre-learning dDMM.

conditions, the difficulty in getting water, and the topography line a desert. In addition, "breeding" was discussed between the students and the lecturer during the online class for active use of genetic mutations, which possibly led to the differences.

4 Summary and Future Work

It was shown that each student came to think more realistically about agriculture in space due to the real-time online class, because dDMMs were influenced by the topic of lecture and discussions, which was seen in the statical text analysis of pre-learning and post-learning dDMMs with the KH Coder. So, the dDMM application is an effective tool in a real-time online class, and its advantage is that several dDMM data can be easily compared on one screen. Here, the practical examples on online class were shown, but it is not an online-only tool, so it can also be used effectively on offline courses. The dDMM application can be also useful for writing a learning portfolio. In a course of computer networks, we assigned students to compile portfolios comparing pre-learning and post-learning dDMMs as evidence, in order to indicate what they learned in the course.

We have been developing the dDMM application as a collaborative tool, but we have not yet used it in online multiple groups, which is assumed in typical collaborative learning. We are considering implementing the dDMM application the function such as automatic grouping, based on pre-learning dDMMs to support collaborative learning. Then, we will apply it on a class with multiple groups to investigate its effects in collaborative learning. We have used the dDMM application in a paper-based style for group work in an offline class in a high school. But we did not undertake analysis because of insufficient data. We will also implement multilingual support using Google Translate for users whose native language is not Japanese. In addition, we have been improving the dDMM application adding a function to input images for symbolising the words in the top nine cells of dDMM. This function is very useful for elementary and junior high school students, who may not be good at verbalising their ideas.

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